U.S. ATLAS 99-20

Revised

U.S. ATLAS Construction Project Management Plan

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Submission and Approvals

This is a Revision of the U.S. ATLAS Project Management which was approved jointly by the U.S. Department of Energy and the National Science Foundation.

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TABLE OF CONTENTS

LIST OF TABLES

APPENDICES

LIST OF ABBREVIATIONS

ACWP	Actual Cost of Work Performed
ALD	BNL Associate Laboratory Director
APM	Associate Project Manager for Physics and Computing
AY	At Year (referring to a dollar value)
BCP	Baseline Change Proposal
BCWP	Budgeted Cost of Work Performed
BCWS	Budged Cost of Work Schedules
BHG	Brookhaven Group
BNL	Brookhaven National Laboratory
CB	ATLAS Collaboration Board
CCB	Change Control Board
CERN	European Laboratory for Particle Physics
CH	Chicago Operations Office
DHEP	Division of High Energy Physics
DOE	Department of Energy
EDIA	Engineering Design, Inspection and Assembly
EDMS	Engineering Data Management System
ES&H	Environmental Safety and Health
HEP	DOE Headquarters Office of High Energy Physics
IB	Institutional Board
IMOU	Interim Memorandum of Understanding
JOG	Joint Oversight Group
LHC	Large Hadron Collider
LHCC	CERN LHC Committee
MOU	Memorandum of Understanding
MRE	Major Research Equipment
NSF	National Science Foundation
PAP	Project Advisory Panel
PBS	Product Breakdown Structure
PCAP	Physics and Computing Advisory Panel
PL	ATLAS Project Leader
PM	U.S. ATLAS Project Manager
PMCS	Project Management Control System
PMP	Project Management Plan
PO	U.S. ATLAS Project Office
QAP	Quality Assurance Plan
R&D	Research and Development
RRB	ATLAS Resource Review Board
SC	DOE Office of Science
SM	U.S. ATLAS Subsystem Manager
TDR	Technical Design Report
TRT	Transition Radiation Tracker
WBS	Work Breakdown Structure

1 Introduction

1.1 Overview of the Project Management Plan

The U.S. Department of Energy and National Science Foundation are supporting the U.S. involvement in the two large detectors for the CERN Large Hadron Collider (LHC), ATLAS and CMS, through the fabrication of equipment and systems for those detectors as well as the U.S. involvement in the research program. The research program is not specifically addressed here, but is covered in a separate plan. The fabrication effort is being carried out at, or under the supervision of, U.S. universities and national laboratories, under terms and conditions described in the International Collaboration Agreement (signed in Washington on December 8, 1997) and its Experimental Protocol (signed at CERN on December 19, 1997), between CERN, and the DOE and NSF. According to these agreements, fixed total dollar contributions, to be expended over a period of about 9 years, are separately specified for DOE and NSF. These funds are to be used by the U.S. ATLAS and CMS collaborators to supply equipment and systems for the detectors. The ATLAS Collaboration has prepared international Memoranda-of-Understanding (MOUs) agreed to by all the funding agencies involved in each detector. These include Interim Memoranda of Understanding (IMOUs) covering work to be done in 1996 and 1997, and MOUs (prepared in 1998) defining responsibilities for the full detector construction effort. The U.S. concurrence with the MOU (Appendix 1) was expressed in the form of a list of deliverables with the Complete Goals for U.S. Deliverables (Appendix 2) and the Initial Approved Scope of U.S. Deliverables (Appendix 3).

This Project Management Plan (PMP) is relevant to the design and fabrication of equipment and systems (the U.S. ATLAS Construction Project) to be supplied by the U.S. ATLAS Collaboration for the ATLAS detector. Separate management plans will be prepared for the research program. This PMP defines the organization, systems and processes employed to manage the U.S. ATLAS Construction Project. The U.S. ATLAS Collaboration presently consists of scientists and engineers from 29 U.S. universities and three national laboratories, and is part of the international ATLAS Collaboration that has overall responsibility for the ATLAS detector. The Host Laboratory for the U.S. ATLAS Construction Project is Brookhaven National Laboratory, where the Project Office is located.

The DOE and NSF have chosen to treat the totality of activities necessary for the U.S. to execute the construction of the scientific and technical components agreed to by the DOE, NSF, and CERN as a single project, the U.S. LHC Construction Project. The U.S. LHC Construction Project includes three elements, the U.S. ATLAS, U.S. CMS, and the U.S. LHC Accelerator Construction Projects. The management structures, roles, and responsibilities are described in the U.S. LHC Project Execution Plan (PEP). The PEP takes precedence over this Project Management Plan.

Since the U.S. ATLAS Construction Project is funded by both DOE and NSF, a Joint Oversight Group has been formed by the two agencies to perform periodic reviews and assess technical, schedule and cost performance. The specific responsibilities of the JOG are addressed in a Memorandum of Understanding between the DOE and the NSF on U.S. Participation in the LHC Program.

1.2 Construction Project Description

The ATLAS detector consists of an inner tracking system with silicon pixels, silicon strips and a transition radiation tracker (TRT); a liquid argon electromagnetic and forward calorimeter; a scintillating tile hadronic calorimeter; a muon spectrometer; and a trigger and data acquisition system. There are superconducting solenoid and toroid magnets to allow sign determinations and momentum measurements for charged particle products of the collisions. U.S. groups are involved in almost all of these components of the ATLAS detector, which is being built by a large international collaboration. Detailed descriptions of all these systems are given in the Technical Design Reports (TDRs) which for most subsystems have been reviewed by the CERN LHC-Committee (LHCC) and approved by the Director General of CERN.

2 ATLAS Objectives

2.1 Scientific Objectives

The fundamental unanswered problem of elementary particle physics relates to the understanding of the mechanism that generates the masses of the W and Z gauge bosons and of quarks and leptons. To attack this problem, one requires an experiment that can produce a large rate of particle collisions of very high energy. The LHC will collide protons against protons every 25 ns with a center-of-mass energy of 14 TeV and a design luminosity of 10^{34} cm^{-2} s^{-1}. It will probably require a few years after turn-on to reach the full design luminosity.

The detector will have to be capable of reconstructing the interesting final states. It must be designed to fully utilize the high luminosity so that detailed studies of rare phenomena can be carried out. While the primary goal of the experiment is to determine the mechanism of electroweak symmetry breaking via the detection of Higgs bosons, supersymmetric particles or structure in the WW scattering amplitude, the new energy regime will also offer the opportunity to probe for quark substructure or discover new exotic particles. The detector must be sufficiently versatile to detect and identify the final state products of these processes. In particular, it must be capable of reconstructing the momenta and directions of quarks (hadronic jets, tagged by their flavors where possible), electrons, muons, taus, and photons, and be sensitive to energy carried off by weakly interacting particles such as neutrinos that cannot be directly detected. The ATLAS detector is designed to have all of these capabilities.

2.2 Technical Objectives

The ATLAS detector is designed to perform a comprehensive study of the source of electroweak symmetry breaking. It is expected to operate for twenty or more years at the CERN LHC, observing collisions of protons, and recording more than 10^7 events per year. The critical objectives to achieve these goals are:

- Excellent photon and electron identification capability, as well as energy and directional resolution.
- Efficient charged particle track reconstruction and good momentum resolution.
- Excellent muon identification capability and momentum resolution.
- Well-understood trigger system to go from 1 GHz raw interaction rate to ~100 Hz readout rate without loss of interesting signals.
- Hermetic calorimetry coverage to allow accurate measurement of direction and magnitude of energy flow, and excellent reconstruction of missing transverse momentum.
- Efficient tagging of b-decays and b-jets.

2.3 Cost Objectives

The U.S. ATLAS construction project cost objective is $163.75M. The detailed cost baseline is presented in Appendix 8-1.

2.4 Schedule Objectives

The ATLAS construction project was initiated in FY 1996, and is scheduled for a 10-year design and fabrication period beginning in the first quarter of FY 1996, and finishing in the fourth quarter in FY 2005. This period is to be followed by the first collisions at the LHC. The project summary schedule is shown in Appendix 8-2. The Major Project Milestones given in Appendix 5 require approval of the DOE/NSF Project Manager. These milestones form the initial schedule baseline.

3 ATLAS Organization

3.1 Introduction

The U.S. ATLAS Construction Project operates within the context of the internationally funded ATLAS experiment located at CERN. The general responsibilities of the U.S. participants are described in Article VI of the Experiments Protocol signed between CERN, and DOE and NSF. In essence, they have responsibilities for R&D, engineering design, prototyping, fabrication, installation and normal maintenance and operation of detector systems and components as agreed to and described in the IMOU, the MOU, and their addenda. The responsibilities of the CERN management are described in Article VIII of the same Protocol.

The U.S. ATLAS Construction Project is managed by the U.S. ATLAS Project Office, located at Brookhaven National Laboratory (BNL), under the direction of the designated U.S. ATLAS Project Manager (hereafter referred to as the Project Manager or PM). The Project Manager has the principal authority for day-to-day management and administration of all project activities. The Director of BNL, or his/her designee, is responsible for management oversight of the project and DOE and NSF jointly provide requirements, objectives and funding.

3.2 The International ATLAS Project and its Management

The large general-purpose LHC experiments rank among the most ambitious and challenging technical undertakings ever proposed by the international scientific community. The inter-regional collaborations assembled to design, implement and execute these experiments face unprecedented sociological challenges in marshaling efficiently their enormous, yet highly decentralized, human and economic resources. The overall ATLAS approach to this challenge is to base most of the ATLAS governance on the collaborating institutions rather than on any national blocks. Thus the principal organizational entity in ATLAS is the Collaboration Board (CB), consisting of one voting representative from each collaborating institution, regardless of size or national origin.

The CB is the entity within ATLAS that must ratify all policy and technical decisions, and all appointments to official ATLAS positions. It is chaired by an elected Chairperson who serves for a non-renewable two-year term. The Deputy Chairperson, elected in the middle of the Chairperson's term, succeeds the Chairperson at the end of his/her term. The CB Chairperson has appointed (and the CB ratified) a smaller advisory group with whom he/she can readily consult between ATLAS collaboration meetings.

Executive responsibility within ATLAS is carried by the Spokesperson who is elected by the CB to a renewable three-year term. The Spokesperson is empowered to nominate one or two deputies (there is presently one) to serve for the duration of the Spokesperson's term in office. The Spokesperson represents the ATLAS Collaboration before all relevant bodies, and carries the overall responsibility for the ATLAS Detector Project.

The ATLAS central management team also includes Technical and Resource Coordinators, both CERN staff members whose appointments to their roles require CERN management approval. The Technical Coordinator has the overall responsibility for the technical aspects of the detector construction. This includes responsibility for the integration of the ATLAS subsystems and for coordinating the CERN infrastructure, including the installation of the experiment in the surface and underground areas. The Resource Coordinator is responsible for budget and manpower planning, including securing the Common Projects resources, and for negotiating the MOUs with the various funding agencies.

The ATLAS Spokesperson chairs an Executive Board (EB), consisting of high-level representatives of all the major detector subsystems plus the Technical and Resource Coordinators. The Executive Board directs the execution of the ATLAS project according to the policies established by the Collaboration Board.

Each ATLAS subsystem has a Project Leader directly and ultimately responsible for ensuring that the design and construction of the corresponding subsystem are carried out on schedule, within the cost ceiling, and in a way that guarantees the required performance and reliability. Each major ATLAS subsystem is overseen by a technically-oriented Steering Group, with expertise in all the relevant technical areas.

It is understood that the U.S.-ATLAS management must operate within the regulations imposed by the U.S. funding agencies, the funding appropriated by the U.S. Congress, and the terms of the U.S.-CERN Protocol on LHC Experiments. Subject to these limitations, it is expected that the U.S.-ATLAS management implements all decisions taken by the ATLAS Resource Review Board (RRB) and the Collaboration Board. The RRB comprises representatives from all ATLAS funding agencies and the managements of CERN and the ATLAS Collaboration. The U.S. has DOE and NSF representatives. The RRB meets twice per year, usually in April and October.

The role of the RRB includes:

- reaching agreement on the ATLAS Memorandum of Understanding
- monitoring the Common Projects and the use of the Common Funds
- monitoring the general financial and manpower support
- reaching agreement on a maintenance and operation procedure and monitoring its functioning
- endorsing the annual construction and maintenance and operation budgets of the detector

As far as project execution is concerned, decisions by the ATLAS Executive Board (EB) should also be adopted directly or, if not compatible with the U.S. operating procedures, adapted so as to match the EB decision as closely as possible. In the latter case ATLAS management should be consulted and informed about the detailed U.S. implementation.

ATLAS has adopted procedures for quality control and change requests valid for all Collaboration partners. For example, a Product Breakdown Structure (PBS/WBS) structure has been established and a global Engineering Data Management System (EDMS) is used to manage documents pertaining to ATLAS Technical Coordination, the ATLAS Detector, General Facilities, Assembly and Test Areas and Offline Computing. A CERN Drawing Directory (CDD) is used to manage all drawings. It is understood that the U.S. institutions use these management procedures and tools at the same level as all the other ATLAS institutions.

3.3 Membership of the U.S. ATLAS Collaboration

The U.S. ATLAS Collaboration consists of physicists and engineers from all U.S. institutions collaborating on the ATLAS experiment at the CERN LHC. Table 3-1 shows a list of the participating institutions. Individuals from these institutions share responsibility for the construction and execution of the experiment with collaborators from the international high-energy physics community outside the U.S.

Table 3-1: U.S. ATLAS Participating Institutions

(Agency support shown in parentheses)

Argonne National Laboratory (DOE)
University of Arizona (DOE)
Boston University (DOE)
Brandeis University (DOE/NSF)
Brookhaven National Laboratory (DOE)
University of California, Berkeley/Lawrence Berkeley National Laboratory (DOE)
University of California, Irvine (DOE/NSF)
University of California, Santa Cruz (DOE/NSF)
University of Chicago (NSF)
Columbia University (Nevis Laboratory) (NSF)
Duke University (DOE)
Hampton University (NSF)
Harvard University (DOE/NSF)
University of Illinois, Urbana-Champaign (DOE)
Indiana University (DOE)
Iowa State University (DOE)
Massachusetts Institute of Technology (DOE)
University of Michigan (DOE)
Michigan State University (NSF)
University of New Mexico (DOE)
State University of New York at Albany (DOE)
State University of New York at Stony Brook (DOE/NSF)
Northern Illinois University (NSF)
Ohio State University (DOE)
University of Oklahoma/Langston University (DOE)
University of Pennsylvania (DOE)
University of Pittsburgh (DOE/NSF)
University of Rochester (DOE/NSF)
Southern Methodist University (DOE)
University of Texas at Arlington (DOE/NSF)
Tufts University (DOE)
University of Washington (NSF)
University of Wisconsin, Madison (DOE)

3.4 The U.S. ATLAS Management Organization

To facilitate interactions with the U.S. funding agencies and for effective management of U.S. ATLAS activities and resources, a project management structure has been established with the Project Office located at BNL. Appendix 7-1 shows the organization chart for U.S. ATLAS. This organization is headed by a U.S. ATLAS Project Manager supported by a Project Office along with U.S. Subsystem Managers for each of the major detector elements in which the U.S. is involved. The organization also includes an Institutional Board with representation from each collaborating institution, and an Executive Committee. The responsibilities of each will be described below. The U.S. ATLAS planning and management is being done in close cooperation with the overall ATLAS management. The U.S. Subsystem Managers interact closely with the corresponding overall ATLAS Subsystem Project Leaders, and the U.S. ATLAS Project Manager maintains close contact with the ATLAS Spokesperson, and the Technical and Resource Coordinators.

3.4.1 U.S. ATLAS Project Manager

The U.S. ATLAS Project Manager (PM) has the responsibility of providing programmatic coordination and management for the U.S. ATLAS Construction Project. Responsibilities for the Research Program are addressed in separate documents. He/she represents the U.S. ATLAS Project in interactions with overall ATLAS management, CERN, DOE, NSF, the universities and national laboratories involved and BNL, the Host Laboratory. The PM is appointed by the Director of BNL and with concurrence of the DOE and NSF upon recommendation from the U.S. ATLAS Collaboration. The PM will serve as long as there is the continuing confidence of the Collaboration and the funding agencies. He/she reports to the BNL Director (or his/her appointed representative). The PM is advised in this role by an Executive Committee, which includes all U.S. Subsystem Managers, as described below. The PM may select a Deputy to assist him. With respect to technical, budgetary, and managerial issues, the U.S. Subsystem Managers, augmented by the Institutional Board Convener, act as a subcommittee of the Executive Committee to provide advice to the PM on a regular basis. Consultation with this subcommittee is part of the process by which the PM makes important technical and managerial decisions. An example of such a managerial decision would be a modification of institutional responsibilities.

The management responsibilities of the U.S. ATLAS Project Manager include:

1. Appointing, after consultation with the Collaboration, of U.S. Subsystem Managers (SMs) responsible for coordination and management within each detector subsystem. The SMs will serve with the PM's continuing concurrence.

2. Preparing the yearly funding requests to DOE and NSF for the anticipated U.S. ATLAS activities.

3. Recommending to DOE and NSF the institution-by-institution funding allocations to support the U.S. ATLAS efforts. These recommendations will be made with the advice of the SMs, and the U.S ATLAS Executive Committee.

4. Approving budgets and allocating funds in consultation with the SMs and managing contingency budgets in accord with the Change Control Process in Section 7.

5. Establishing, with the support of BNL management, a U.S. ATLAS Project Office with appropriate support services.

6. Working with BNL management to set up and respond to whatever advisory or other mechanisms BNL management feels necessary to carry out its oversight responsibility.

7. Keeping the BNL Director or his chosen representative well informed on the progress of the U.S. ATLAS effort, and reporting promptly any problems whose solutions may benefit from the joint efforts of the PM and BNL management.

8. Interacting with CERN on issues affecting resource allocation and availability, preparation of the international MOUs defining U.S. deliverables and concurring in these MOUs.

9. Advising the DOE and NSF representatives at the ATLAS Resource Review Board meetings.

10. Negotiating and signing the U.S. Institutional MOUs representing agreements between the U.S. ATLAS Project Office and the U.S. ATLAS collaborating institutions specifying the deliverables to be provided and the resources available on an institution-by-institution basis.

11. Periodically reporting on project status and issues to the Joint Oversight Group.

12. Conducting, at least twice a year, meetings with the U.S. ATLAS Executive Committee to discuss budget planning, milestones, and other U.S. ATLAS management issues.

13. Making periodic reports to the U.S. ATLAS Institutional Board to ensure that the Collaboration is fully informed about important issues.

14. Overseeing ES&H Management.

The channels for funding, reporting, and transmission of both types of MOUs are shown in Appendix 7-2. DOE funding will be a mixture of grants and Research Contracts through BNL. NSF funding will be through subcontracts through Columbia University. Further details on the identities and roles of the various participants in the U.S. ATLAS Collaboration governance are given below.

3.4.2 Institutional Board

The U.S. ATLAS Collaboration has an Institutional Board (IB) with one member from each collaborating institution and a Convener elected by the Board. The Convener serves for a two-year renewable term. The IB will normally meet several times per year. Under normal circumstances the meetings are open to the Collaboration, although closed meetings may be called by the Convener to discuss detailed or difficult issues. All voting is by IB members only, except in the case of the absence of a member when the missing member may appoint an alternate.

The IB members represent the interests of their institutions and serve as points of contact between the U.S. ATLAS management structure and the collaborators from their institutions. They are selected by the ATLAS participants from their institutions.

The Institutional Board deals with general policy issues affecting the U.S. ATLAS Collaboration. As chairman of this board the Convener will organize meetings on issues of general interest that arise and will speak for U.S. ATLAS on issues that affect the Collaboration. The Convener also will recommend for ratification to the Institutional Board the ad hoc committees charged with running the elections for the Convener and for the membership of the Executive Committee, as described in the next section. The Convener will recommend to the Institutional Board the establishment of any standing committees to deal with collaboration wide issues if the need arises. The Institutional Board also provides its recommendation on the appointment of the Project Manager to the BNL Director, and DOE and the NSF.

3.4.3 Executive Committee

The Executive Committee advises the Project Manager on global and policy issues affecting the U.S. ATLAS Collaboration or the U.S. ATLAS Construction Project. It also deals with issues external to the U.S. ATLAS Construction Project such as education, computing, physics analysis etc. The Executive Committee has meetings at least twice per year. Its membership is the following:

- The Deputy Project Manager,
- Associate Project Manager for Physics and Computing
- Subsystem Managers,
- The Subsystem Representatives from each subsystem in which U.S. groups are playing a major role, their number being given in parentheses:
  - Semiconductor tracker (1),
  - TRT (1),
  - Liquid argon calorimeter and forward calorimeter (2),
  - Tile calorimeter (1),
  - Muon spectrometer (2),
  - Trigger/DAQ subsystems (1),
- The Education Coordinator,
- The U.S. members of the overall ATLAS Executive Board,
- The Convener of the Institutional Board.

The Subsystem Representatives are elected for two-year renewable terms by the IB members whose institutions are associated with the given subsystem.

The Education Coordinator, also elected for a two-year renewable term by the IB, is expected to actively promote educational programs associated with ATLAS and with the U.S. member institutions, and to report to the Executive Committee on these issues. He/she will also act as liaison to DOE and NSF for educational activities. The intended audiences for these education activities are a) the general public, b) secondary school students, c) undergraduates, and d) primary and secondary school teachers.

3.4.4 Associate Project Manager for Physics and Computing

The Associate Project Manager for Physics and Computing (APM) is responsible for the technical, schedule and cost aspects of the U.S. ATLAS Computing Project. (The scope of the U.S. ATLAS Computing Project is part of the U.S. preparations for participation in the ATLAS research program and is not part of the U.S. ATLAS Construction Project.) The Computing Project will follow all the features of this Project Management Plan in terms of defining a WBS for the deliverables, a detailed cost estimate and resource loaded schedule, controls and reporting. The APM develops the budgets for the institutions participating. The U.S. ATLAS Project Manager appoints the APM with concurrence from the Executive Committee. The APM appoints Software, Facilities and Physics Subsystem Managers with the concurrence of the Executive Committee.

3.4.5 Subsystem Managers

The Subsystem Managers are responsible for the technical, schedule, and cost aspects of their subsystems. They develop the budgets for the institutions participating in their subsystems. They are appointed by the U.S. ATLAS Project Manager upon recommendation of the IB members whose institutions are involved in that subsystem. The Subsystem Managers, augmented by the Institutional Board Convener, also act as a subcommittee of the Executive Committee advising the PM on technical, budgetary, and managerial issues relevant to the U.S. ATLAS Project. Prior to making important technical and managerial decisions, the PM will consult with this subcommittee.

3.4.6 Brookhaven National Laboratory (BNL) and Columbia University

The DOE and NSF have assigned BNL management oversight responsibility for the U.S. ATLAS Construction Project, as well as the U.S. ATLAS Research Program. The BNL Director has the responsibility to assure that the detector effort is being soundly managed, that technical progress is proceeding in a timely way, that technical or financial problems, if any, are being identified and properly addressed, and that an adequate management organization is in place and functioning. The BNL Director has delegated certain responsibilities and authorities to the Associate Laboratory Director for High Energy and Nuclear Physics. The Associate Director is responsible for day-to-day management oversight of the Construction Project and the U.S. ATLAS Project Manager reports to him. Specific responsibilities of the BNL Directorate include:

1. Acting on recommendations of the U.S. ATLAS Collaboration, appoint the U.S. ATLAS Project Manager, subject to the concurrence of the Joint Oversight Group;
2. Establish an advisory structure external to the U.S. ATLAS project for the purpose of monitoring both management and technical progress for all U.S. ATLAS activities;
3. Assure that the Project Manager has adequate staff and support, and that U.S. ATLAS management systems are matched to the needs of the project;
4. Consult regularly with the Project Manager to assure timely resolution of management challenges;
5. Concur with the International Memorandum of Understanding specifying U.S. deliverables for the U.S. ATLAS project funded by DOE and NSF.
6. Concur with the institutional Memoranda of Understanding for the U.S. ATLAS collaborating institutions that specify the deliverables to be provided and the resources available for each institution;
7. Ensure that accurate and complete project reporting to the DOE and NSF is provided in a timely manner.

The NSF Division of Physics has delegated financial accountability to Columbia University inclusive of line management authority, responsibility and accountability for overall project implementation, and contract administration. The Director of Nevis Laboratory is responsible for dispersal of NSF funds according to the allocations recommended by the U.S. ATLAS Project Manager and consistent with NSF Major Research Equipment (MRE) policies.

3.4.7 Project Advisory Panel

The Project Advisory Panel (PAP) is appointed by the Brookhaven Associate Laboratory Director, High Energy & Nuclear Physics. The role of the PAP in the U.S. ATLAS Detector Project is to provide oversight of the work performed in the Project plus advice to Laboratory management on the rate of progress in and adherence to the project plan as it relates to cost, schedule and technical performance. The primary mechanism for performing this oversight role is attendance at the Project Manager's periodic technical reviews of the U.S. ATLAS subsystems, followed by discussions among the attending PAP members with Project principals and Subsystem Managers. If necessary, additional other mechanisms may be employed as deemed necessary to exercise the oversight function. These may include special reviews or meetings and attendance at Department of Energy/National Science Foundation (DOE/NSF) reviews of the U.S. ATLAS Project. The PAP reports to Laboratory management by means of oral discussions plus a written report following each significant PAP review. PAP reports are transmitted to DOE and NSF.

3.4.8 Physics and Computing Advisory Panel

The Physics and Computing Advisory Panel (PCAP) is appointed by U.S. ATLAS Project Manager. The role of the PCAP in the U.S. ATLAS Detector Project will be to provide advice to the PM on the rate of progress in and adherence to the Computing project plan as it relates to cost, schedule and technical performance. The activities of the PCAP are described in more detail in the project management plan for U.S. ATLAS Software and Computing.

3.5 Department Of Energy (DOE) and National Science Foundation (NSF)

The Department of Energy (DOE) and the National Science Foundation (NSF) are the funding agencies for the U.S. ATLAS Construction Project. As such they monitor technical, schedule, and cost progress for the program. The organizational structure is shown in Appendix 7-3.

The DOE has delegated responsibility for the U.S. ATLAS activities to the Office of Science, Division of High Energy Physics. The NSF has delegated responsibility for the U.S. ATLAS project to the Division of Physics, Elementary Particle Physics Programs.

The U.S. ATLAS Project receives substantial support from both DOE and NSF. Almost all the subsystems involve close collaboration between DOE and NSF supported groups. It is therefore essential that DOE and NSF oversight be closely coordinated. The DOE and NSF have agreed to establish a Joint Oversight Group (JOG) as the highest level of joint U.S. LHC Program management oversight. The JOG has responsibility to see that the U.S. LHC Program is effectively managed and executed so as to meet the commitments made to CERN under the International Agreement and its Protocols. The JOG provides programmatic guidance and direction for the U.S. LHC Construction Project and the U.S. LHC Research Program and coordinates DOE and NSF policy and procedures with respect to both. The JOG approves and oversees implementation of the U.S. LHC Project Execution Plan (PEP) and individual Project Management Plans which are incorporated into the PEP including the U.S. ATLAS Construction Project Management Plan.

All documents approved by JOG are subject to the rules and practices of each agency and the signed Agreements and Protocols.

The U.S. LHC Program Office and U.S. LHC Project Office are established to carry out the management functions described in the PEP. As the DOE has been designated lead agency for the U.S. LHC Program, the U.S. LHC Program Manager and the U.S. LHC Project Manager, who respectively head the program and project offices, will generally be DOE employees. The Associate U.S. LHC Program Manager will generally be an NSF employee.

U.S. LHC Program Office

The U.S. LHC Program Office has the overall responsibility for day-to-day program management of the U.S. LHC Program as described in the PEP. In this capacity, it reports directly to the JOG and acts as its executive arm. The office is jointly responsible with the U.S. LHC Project Office for preparation and maintenance of the PEP, and interfaces with the DOE Division of High Energy Physics and the NSF Division of Physics, which are the respective agency offices charged with responsibility to oversee the U.S. LHC Program. The Program Manager and Associate Program Manager are responsible for coordination between the agencies of the joint oversight activities described in the Memorandum of Understanding between DOE and NSF and in the PEP.

U.S. LHC Project Office

The U.S. LHC Project Office is responsible for day-to-day oversight of the U.S. LHC Projects as described in the PEP. In this capacity, the U.S. LHC Project Manager reports to the U.S. LHC Program Manager, and routinely interfaces with the Project Managers for each of the U.S. LHC Projects. These managers represent the contractors and grantees to DOE and NSF. These contractors and grantees have direct responsibility to design, fabricate, and provide to CERN the goods and services agreed in the International Agreement and Protocols.

3.6 Detector Responsibilities

General responsibilities for the design and fabrication of the detector components have been assigned through the traditional process of matching interests, capabilities, and resources of the members of the U.S. ATLAS Collaboration. These responsibilities are specified in the international Memorandum of Understanding (MOU) agreed to by all the relevant funding agencies. U.S. institution-by-institution responsibilities are detailed in Institutional Memoranda of Understanding (MOUs) executed by the Project Office with the individual U.S. institutions. Appendix 7-4 lists by detector system the U.S. institutions participating in the design, fabrication and testing of U.S. ATLAS Construction Project deliverables. Responsibilities for physics and computing are addressed in separate documents.

4 Work Breakdown Structure

All work required for the successful completion of the U.S. ATLAS Construction Project is organized into a Work Breakdown Structure (WBS). The WBS completely defines the scope of work, the deliverables, and is the basis for planning, cost and schedule estimates, and performance measurement.

The WBS has been expanded to a level sufficient to allow definition of individual tasks/elements for which cost can be reasonably estimated. Appendix 7-5 shows the WBS Index at Level 3, which includes the breakdown of individual subsystems and other support functions such as Common Projects, Education and Project Management. Appendix 6 shows to Level 3 of the WBS Dictionary. Individual subsystems have been further expanded to include WBS Levels 4 and 5 to define work down to the design, prototype, production and installation phases of the project.

The Pixel subsystem, WBS 1.1.1, and the Trigger/DAQ subsystem, WBS 1.6, are initially funded as level-of-effort R&D. These subsystems will be included in the project technical baseline as soon as the ATLAS Technical Design Reports for these systems are approved.

Cost estimates have been generated at the most detailed level of the WBS and summed to the top level to determine the total cost for the U.S. ATLAS Construction Project. The WBS also provides a basis for resource-loaded schedules to be prepared with durations assigned to each task at the detailed level. Interdependencies (project logic) will be defined between the WBS elements to generate detailed schedules that time-phase each task. The integration of schedule and cost data provides a time-phased budget that can be used for performance measurement.

A complete list of goals for U.S. deliverables has been derived from key tasks in the WBS and is shown in Appendix 2. This list forms the basis of the MOU with ATLAS.

To take into account uncertainties in the cost estimates, contingency amounts based on a risk analysis for each WBS element, are added to the costs. The result is a large contingency which has been created to avoid the risk of overruns on this project. A significant level of management contingency is also identified for each Level 2 WBS item. Certain items in each subsystem have been identified in Appendix 2, the Full Goals of U.S. ATLAS Deliverables, but not listed in Appendix 3, the Initial Approved Scope of Deliverables. The items in Appendix 3 are the Technical Baseline approval by the DOE/NSF Joint Oversight Group.

5 Project Schedules and Milestones

Schedules for the U.S. ATLAS are generated at three levels of detail based on the WBS. Detailed, intermediate and summary schedules are generated using commercially-available project management software. All milestones are tracked in the Milestone Log including those in Appendix 4 and 5.

5.1 Detailed Schedules

The detailed schedules have been generated by each Subsystem Manager to show timelines and project logic for all efforts associated with design, prototype, production, delivery and installation of all deliverables required to be provided for that subsystem. Activity duration, start and completion dates are coordinated with ATLAS schedule activities to ensure that the completion date for ATLAS is maintained. These activities are logically interconnected to form networks with all other elements that comprise the subsystem. These schedules are maintained by the Subsystem Managers and are kept consistent with the current cost estimate. The detailed schedules from each subsystem will be used to generate both the intermediate and summary schedules that are used for the schedule and cost baseline.

5.2 Intermediate Schedules

Specific milestones are selected from the detailed schedules to define transition points that are used to integrate all elements of the U.S. ATLAS Construction Project into the overall ATLAS schedule. These schedules mimic the detailed schedules but are limited in detail to WBS Level 5 or above. Relationships between activities of the different subsystems and the constraining ATLAS milestones form a network that is used to calculate critical paths. Cost estimates are summarized to the level of these intermediate schedules to form a time-phased budget that is used for performance measurement. These baseline schedules and the time phased costs are maintained by the Project Office and are subject to baseline controls. Schedules are updated by the Project Office on a periodic basis using turnaround documents filled in by the Subsystem Managers.

5.3 Summary Schedule

Key ATLAS milestones and selected milestones from the baseline schedules are incorporated into a summary milestone schedule that is used for reporting purposes. This summary schedule addresses all subsystems and provides an overview of work in process. A summary logic network is also maintained to show critical paths. These schedules are updated based on status inputs to the intermediate schedules, and used for periodic reporting.

6 Cost Estimate

6.1 Cost Objectives

The total estimated cost of the U.S. ATLAS detector components is presented in Appendix 8-1. The common projects are specified in the ATLAS experiment to represent 44% of the total deliverables, as measured in Swiss-Franc CERN accounting. Part of the U.S. obligation to the Common Projects are the barrel cryostat and feedthroughs in WBS 1.3, Liquid Argon Calorimeter; and computing equipment included in WBS 1.6, Trigger/DAQ. Institutional Dues and other items to be resolved (or Common Fund) are in WBS 1.7. The Institutional Dues are 100kCHF/institution spread over 8 years starting in FY 1997.

Cost estimates are prepared by the Subsystem Managers using the WBS. All estimates were initially made in FY 1997 dollars and include all labor and material required to complete the work comprising the U.S. ATLAS Project and specified in the international MOU. The contingency calculation has been based on a combination of the design maturity, and the technical, cost, design and schedule risks associated with each element of the WBS. These costs are summed to a single line that will be controlled by the Project Office. Escalation is based on the latest DOE factors. A breakdown of the costs by Level 2 systems is shown in Appendix 8-1 and the funding profile from the DOE and NSF by fiscal year in Appendix 8-3 in At Year Dollars (AY$).

A Management Contingency has been defined to reserve funds for the items that are in Appendix 2 but not in Appendix 3. Starting in FY 2000, baseline scope increases will be considered to be funded from the Management Contingency in Appendix 8-2 assuming performance in that subsystem indicates that sufficient funds will remain at completion.

7 Management and Control System

The U.S. ATLAS project management control system (PMCS) incorporates three primary elements:

- Baseline Development - Defining project scope and establishing the necessary cost and schedule baselines and work execution plans.
- Project Performance - Project status monitoring, reporting and performance analysis.
- Change Control - Management of project baselines and contingency funds.

7.1 Baseline Development

The cost and schedule baseline and the hierarchical relationships are defined in a Work Breakdown Structure. Detailed cost estimates have been developed using appropriate standard estimating methodologies, and integrated with the work scope definition. Schedules and plans have been developed using a disciplined approach that integrates the work scope with the cost estimate. Resources defined in the detailed estimate are applied to the tasks established in the schedule to generate a time-phased budget. These resource-loaded schedules are then aligned to the budget profile and this establishes the schedule and cost baseline. This baseline establishes the Budgeted Cost of Work Scheduled (BCWS) which is used to measure project performance.

7.2 Project Performance

Project performance integrates the work authorization with the funds management and accounting processes to provide a performance analysis capability that is used for reporting to both management and the DOE/NSF.

Funds management is based on funds authorized by both the DOE and NSF that are allocated to the individual institutions in accordance with the baseline estimate and the needs of the project. Funding is planned to occur twice each year. Work authorization is provided for each institution through the U.S. Institutional MOU process which defines the full work scope, including deliverables, and establishes the fiscal year funding. A yearly amendment to the Institutional MOU specifies the funding ceiling to each institution for each subsystem. Standard accounting processes are used to collect actual costs for completed work and to define the funds available for the remainder of the fiscal year. Performance analysis is provided through processing the schedules where comparisons are made between Budgeted Cost of Work Performed (BCWP) and (BCWS) as well as between BCWP and Actual Cost of Work Performed (ACWP). These comparisons provide a determination of project status, and help identify potential problems that cause schedule and cost variances.

The rudiments of performance analysis are embedded in the PCMS. The resource-loaded schedules generated during baseline development are statused on a monthly basis and a comparison of BCWP and BCWS will yield a Schedule Variance (SV) that can be isolated to the specific task or tasks causing the variance. Also a comparison of BCWP and ACWP will yield a Cost Variance that can be attributed to the specific task or tasks causing the variance. This information can be used to establish work-arounds that will hopefully mitigate the problems.

A status report is issued each month that contains the following information:

- U.S. ATLAS Project Managers overview and assessment of the project
- A narrative describing the status of technical work, significant project accomplishments, problems and corrective action if applicable
- A milestone schedule and status report at WBS level 2, identifying completed milestones, slippage and the percentage planned and completed based on cost performance data
- Milestone Log
- Critical path items will be identified for each WBS level 2 Subsystem
- A Cost Schedule Status Report (CSSR) at WBS level 2 identifying BCWS, BCWP, ACWP, SV, CV, Budget at Completion (BAC), Estimate at Completion (EAC) and Variance at Completion
- Variance analysis and corrective action plans where applicable

7.2.1 Reporting

I. Technical Progress
The responsible person in each institution for each subsystem writes the progress by Level 3 WBS each month. Each item should refer to the appropriate Level 5 WBS element and any relevant milestones which are completed. This is due on the 5th of the next month and is sent to the Subsystem Manager. Each Subsystem Manager collates the input and sends it to the Project Manager by the 15th of the month. The Project Manager collates the text, writes an introduction, and finishes the report by the 25th of the month. Reports are placed on Atlas2 in
e:/pub/Incoming/Project_Management/Reporting/Technical_Progress.

II. Costs
Each institution reports on each Level 5 item which is active in the following categories: The reports are placed on Atlas2 in: /pub/Incoming/Project_Management/Reporting/ Financial_Reporting. This is due on the 15th of the month in the Project Office. Reports are provided to the Subsystem Managers.

III. Performance
Each Subsystem Manager provides an estimate of the progress of each WBS Level 5 item by percentage by the 15th of the month. This is accomplished by updating EXCEL spreadsheets located on Atlas2 in /Project_Office/Reporting/Status. These reports of schedule and cost variance can be rolled up to any higher level.

IV. There are schedule status and turn-around documents. These are standardized for schedules and performance measurements at Level 5 of the WBS.
Reporting processes are employed to provide timely, accurate periodic progress reports which enable analysis, evaluation, and corrective action of work scope, schedule, and cost performance against the approved baseline.

Procurements
The U.S. ATLAS Construction Project has defined procurements over $100k as major and subject to PO tracking and control. These are listed in tables in Appendix 9. U.S. ATLAS is working closely with the ATLAS Technical Coordinator in making sure that proper design reviews are conducted at the following stages: conceptual, critical, final. The conceptual stage is when the design has a complete requirements document, there are detailed interface specifications, and there is a model of how to meet these needs.

The critical design review is held when the design has progressed enough to produce prototypes. The final design review is scheduled just before the full production is started. U.S. ATLAS Project Manager approval is required before a bid is solicited for a major procurement. The U.S. ATLAS Project Manager or his Deputy are notified at least two days prior to an actual contract award.

Change Management

The Change Control Process outlined in Figure 7-1 is used to control changes to the Technical, Cost and Schedule Baselines. The membership of the Change Control Board (CCB) consists of the following:

- Chair - Project Manager
- Subsystem Managers
  - Silicon
  - TRT
  - Liquid Argon
  - Tile
  - Muon
  - Trigger/DAQ
- Project Office
  - Mechanical Engineer
  - Electrical Engineer
  - Project Planning Manager

Baseline Change Proposals (BCP) for changes to the detector Technical, Cost and Schedule baselines are referred to the CCB. The following changes are required to be submitted for consideration by the CCB:

> Any change that affects the interaction between various detector systems, the interaction region, the hall safety issues. Such changes also require the concurrence of the ATLAS Change Control Board.
>
> Any change that impacts the performance, the cost or schedule baselines within established thresholds, of the U.S. deliverables.
>
> Any change to the project contingency budget.

The CCB considers the change and its impact, consulting, when necessary, with appropriate outside technical experts. Thresholds for the approval of changes to the detector configuration, cost and schedule are summarized in Table 7-2 along with those responsible for each level of change. After the CCB recommends action on the BCP, the PM approves or rejects the BCP. The BNL Associate Laboratory Director is also required to approve all BCPs involving a cost or schedule change. Upon approval, the change is incorporated into the baseline. An audit trail is provided for each change.

Contingency funds are held by the U.S. ATLAS Project Manager. Contingency funds may be allocated in response to requests for funds required in excess of the base cost. Such requests are reviewed and approved in accordance with the change control procedures.

Table 7-1: U.S. ATLAS Change Control Process

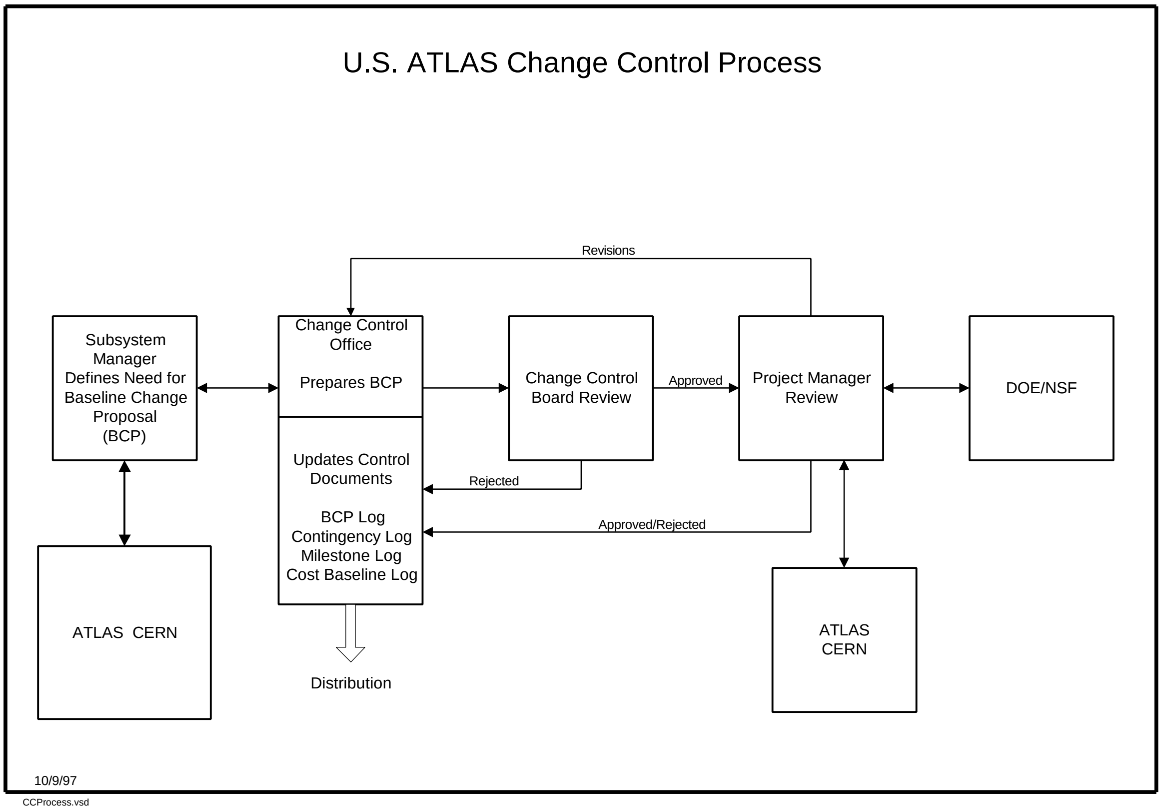


Table 7-2: U.S. ATLAS Change Control Thresholds

	Level 1 DOE/NSF Joint Oversight Group	Level 2 DOE/NSF Project Manager	Level 3 U.S. ATLAS Project Manager and BNL Associate Laboratory Director
Technical	Changes to the project purpose or goals. [Ref. U.S./CERN Agreement and Experiments Protocol]	Changes to the baseline list of deliverables. [Ref. Appendix 3: Initial Approved Scope of U.S. Deliverables]	Changes that do not affect the Level 1 and Level 2 control items. [Ref. U.S. ATLAS Dictionary, U.S. ATLAS 98-03]
Cost	Changes to the Total Project Cost. [Ref. Appendix 8-1: U.S. ATLAS Project Summary Cost Estimate]	Changes to the Level 2 Cost Baseline. [Ref. Appendix 8-1: U.S. ATLAS Project Summary Cost Estimate]	Changes to the cost baseline at WBS Level 3. [Ref. U.S. ATLAS Cost Estimate, U.S. ATLAS 98-04]
Schedule	Greater than 6-month change in a Level 1 milestone [Ref. Appendix 4: U.S. ATLAS Major Project Milestones (Level 1)]	Greater than 3-month change in a Level 2 milestone. [Ref. Appendix 5: U.S. ATLAS Major Project Milestones (Level 2)]	Any change in a Level 3 milestone. [Ref. Appendix 6: U.S. ATLAS Major Project Milestones (Level 3)]

7.3 Host Laboratory Oversight

As discussed earlier, the BNL Director has been charged by DOE and NSF with management oversight responsibility for the U.S. ATLAS activities, and he may delegate this responsibility to the BNL Associate Laboratory Director, High Energy and Nuclear Physics. The Associate Laboratory Director (ALD) has appointed a Project Advisory Panel (PAP) consisting of individuals outside of the U.S. ATLAS Collaboration with expertise in the technical areas relevant to the Project and the management of large projects, to assist him in carrying out his oversight responsibility. The PAP meets at least once per year, or more frequently if required, and its report to the ALD is also transmitted to the DOE/NSF Joint Oversight Group and to the U.S. ATLAS Project Manager. The ALD works with the PM to address any significant problems uncovered in a PAP review.

7.4 Meetings with DOE and NSF

There are regular coordination meetings between the DOE/NSF Project Manager, the Joint Oversight Group, the ALD, and U.S. ATLAS project management personnel for problem identification, discussion of issues, and development of solutions. Written reports on the status of the U.S. ATLAS Construction Project are submitted regularly, as specified in Table 7-3.

Table 7-3: Periodic Reports to DOE and NSF

REPORT	FREQUENCY	SOURCE	RECIPIENTS
Project Status	Monthly	U.S. ATLAS Collaboration	DOE/NSF Program/Project Staff BNL Associate Laboratory Director PAP, Executive Committee Institutional Representatives

7.5 Periodic Reviews

Peer reviews, both internal and external to the Collaboration, provide a critical perspective and important means of validating designs, plans, concepts, and progress. The Project Advisory Panel, appointed by the BNL Associate Laboratory Director provides a major mechanism for project review. The DOE and NSF will set up their own Technical, Management, Cost and Schedule Review Panels to review the research, development, fabrication, assembly and management of the project. In addition, the PM sets up internal review committees to provide technical assessments of various U.S. ATLAS activities, as he/she considers appropriate. Normally, all review reports are made available to members of the U.S. ATLAS Collaboration. However, if a particular report contains some material that, in the opinion of the authority to which the report is addressed, is too sensitive for general dissemination, that material may be deleted and replaced by a summary for the benefit of the Collaboration.

8 Supporting Functions

8.1 Quality Assurance

The overall ATLAS Management has established a Quality Assurance Plan (QAP) at CERN to assure that the detector systems will achieve the technical requirements and reliability needed for operation at the LHC. A general description of the ATLAS QAP is given in ATLAS Document ATL-GE-CERN-QAP-0101.00. It assigns overall responsibility to the ATLAS Spokesperson, assisted by the Technical Coordinator. Furthermore, each ATLAS Project Leader (PL) is assigned the responsibility of implementing a Quality Assurance Plan relevant to his/her subsystem. Each PL is expected to designate a Quality Assurance Representative (QAR) with the authority and organizational freedom to identify potential and actual problems that could result in a degradation of quality, to recommend corrective actions, and to verify implementation of solutions.

Quality Assurance is an integral part of the design, procurement, fabrication, assembly and test of all the systems that are part of the U.S. ATLAS Construction Project. The U.S. ATLAS Project Manager has the overall responsibility for quality assurance. In general, the U.S. ATLAS Subsystem Managers have the quality assurance responsibilities for their subsystems including the following aspects of quality control:

- Identification of those areas, concepts and components which require in-depth studies, prototyping and testing
- Incorporation of necessary acceptance tests into plans and specifications.
- Verification of system performance requirements.
- Documentation of procedures and test results for the fabrication and procurement phase.

8.2 Environmental Safety & Health

The overall ATLAS Management has established an ES&H program at CERN to assure that the detector systems conform to the safety standards in force CERN at the time of delivery to CERN. Again, the U.S. ATLAS Project Manager has the overall responsibility for ensuring that the systems comprising part of the U.S. ATLAS Project satisfy all relevant ATLAS-specified safety regulations and that all institutional ES&H requirements are fully met for U.S. ATLAS work performed in those institutions. In general the U.S. ATLAS Subsystem Managers have responsibility for ES&H issues within their own subsystems including the following:

- Reviewing designs, procedures and practices to identify ES&H potential hazard considerations.
- Assuring that ES&H requirements are met and procedures are followed correctly.

8.3 Property Management

All property will be managed in accordance with established practices of the participating U.S. ATLAS institutions. Property transferred to CERN will be subject to the provision of the International Agreement.

9 Organization of the U.S. ATLAS Project Office (PO)

The U.S. ATLAS Project Office is located at the Host Laboratory, Brookhaven National Laboratory. The PO provides technical coordination, financial and project management support to the Project Manager. The Deputy Project Manager provides direction to PO staff and manages the day to day operations of the PO.

There are two Project Engineers, one mechanical engineer and one electrical engineer, that provide the required technical coordination and support for the overall U.S. ATLAS project. Their duties and responsibilities include:

- Reviewing and validating the rationale and accuracy of technical subsystem cost estimates and schedule baselines.
- Establishing procurement plans.
- Reviewing the feasibility and accuracy of production plans and technology choices.
- Coordinating Quality Assurance, Environmental, Safety and Health issues and compliance.
- Assessing technical and work progress at the collaborating institutions and their vendors.
- Assisting in overall ATLAS detector integration and installation.
- Serving as members of the Change Control Board.

The Administrative Office of the Physics Department at BNL provides the required administrative support for the PO. Specifically the duties and responsibilities are:

- Coordinating and generating the monthly financial report.
- Providing the necessary labor resources to assure the efficient operation of the PO.
- Executing all labor, material and travel purchase actions initiated by the PO.

The Project Planning Manager manages the Project Management Support Group. In addition to directing the activities of this group, he/she has the following duties and responsibilities:

- Developing and maintaining the integrity of the Budget Baseline, Milestone Baseline, Contingency, Baseline Change Proposal (BCP) Logs.
- Establishing the annual funding requirements for each Institution.
- Serving as a member of the Change Control Board.

The Assistant Project Planning Manager, within the Project Management Support Group has primary responsibility for the development and maintenance of the Earned Value portion of the project performance system. Specifically the duties and responsibilities include:

- Developing and validating the accuracy of the Earned Value reporting system
- Establishing Cost Performance Report Formats
- Reporting cost performance
- Doing Variance Analysis

The Senior Project Planning Specialist, within the Project Management Support Group has primary responsibility for the integrity of the U.S. ATLAS schedules. His/her duties and responsibilities include:

- Developing and maintaining the resource loaded project schedules
- Validating consistency of resource loaded schedules with project funding profile
- Establishing schedule links and verifying schedule logic
- Accessing, on a monthly basis, the status of both Earned Value and activity progress of project schedules on a monthly basis
- Performing Critical Path Analysis by identifying and reporting to management critical path items for remedial action and reporting on a monthly basis

10 Review and Modification of this Project Management Plan

After its adoption, this Project Management Plan is periodically reviewed by the Project Manager and the Subsystem Managers as part of the preparation for reviews by the PAP. Proposals for its modification may be initiated by the PM, the Executive Committee, the BNL Associate Laboratory Director, and the funding agencies. Significant changes to the plan require approval of the Joint Oversight Group. Modifications of the Project Management Plan will require approval of the PM, the Associate Laboratory Director, the DOE/NSF Project Manager, and the Joint Oversight Group.

Appendix 1: Letter to Prof. Foa

BROOKHAVEN NATIONAL LABORATORY **UPTON, NEW YORK 11973-5000**

BROOKHAVEN SCIENCE ASSOCIATES
U.S. ATLAS PROJECT OFFICE

April 23, 1998

Professor Lorenzo Foa, Research Director
CERN, CH-1211
Geneva 23, Switzerland

Dear Professor Foa:

The U.S. ATLAS Collaboration Baseline Cost and Project Management Plan (PMP) have now been approved by the DOE and the NSF through their Joint Oversight Group. This good news means that we are ready to proceed on the MOU for the April RRB Meeting. You will recall that at the time of the IMOU signing, the U.S. ATLAS Management and BNL, as the host laboratory in the U.S., were not able to sign the IMOU as such, but were able to achieve the equivalent effect by supplying in a letter a commitment to a specific list of deliverables.

Our situation now is similar, but with some new elements. The U.S.-CERN International Collaboration is now signed, with provisions dealing with a number of issues that are also mentioned in the MOU. The present MOU has a list of deliverables as a central feature of its content. Attached to the present letter is a list of deliverables (labeled "Appendix 2: Complete Goals for U.S. Deliverables" from our PMP) that has carefully been determined to be equivalent to the list in the MOU, but modeled in accordance with the instructions given in Recommendations of our DOE/NSF Baseline Cost Review. We also attach a list of commitments (a subset of Appendix 2 and labeled "Appendix 3: Initial Approved Scope of U.S. Deliverables"). Our Reviewers judged that there are sufficient resources available to commit now to the deliverables in Appendix 3. Furnishing this list of Commitments and Goals then accomplishes one of the goals of the MOU. For the other conditions of the participation in the experiment, we refer to the details in the U.S.-CERN Agreement. It is important to note that the Common Projects already allocated by the RRB, the Barrel Cryostat and signal and high voltage feedthroughs, are included in our commitments. By signing this letter, we believe that we have achieved the goals of the MOU.

We must explain the concepts behind the distinction between Commitments and Goals in our list of deliverables. The origin is the provision of a fixed total sum of funds available for U.S. ATLAS as fixed in the U.S.-CERN Agreement, combined with a desire of the whole ATLAS Collaboration to obtain the full list of deliverables needed for the experiment. A method of optimizing the final set of deliverables was presented to the first meeting of our DOE/NSF Baseline Review by the ATLAS and U.S. ATLAS managements last May. We proceed in two steps. We define a set of goals, and a more restricted set of commitments that we can safely undertake now. We, the U.S. ATLAS leadership, undertake to control the cost and schedule performance of our work well enough so that at a later time, planned to be in 2000 and 2001, we will be able to extend our firm commitments to reach the full goals. We will, of course, continue to involve the ATLAS management in these decisions as we do in all our decision making and reviews.

Sincerely yours,

Thomas B.W. Kirk	William J. Willis
Associate Laboratory Director	U.S. ATLAS Project Manager

Appendix 2: Complete Goals for U.S. Deliverables

Silicon 1.1

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
1.1.1	Pixel System				Deliverables: The U.S. will provide the pixel disk system, with some compone deliverables described below are preliminary, since an ATLAS TDR will only
					Definition of interfaces: Components for the disk system will be provid
1.1.1.1	Pixel Mechanics	8 disks	1.1.1.2 100% 1.1.1.3 25%	 320 100	Deliverables: (1) complete design of pixel disk support/cooling structure and in overall supporting structure; (2) fabrication and delivery of the 8 pixel disk/s level-of-effort contribution to common-fund-supported design of overall pixel of-effort support of LBNL engineering at CERN for pixel design and integrati
					Definition of interfaces: (1) support structure and related mounts by A
1.1.1.2	Pixel Sensors	250 wafers	1.1.2.2 20%	 228	Deliverables: (1) Level-of-effort design and testing (approximately 30% of tot 20% of total) of two prototype orders; and (3) funding of common procureme
					Definition of interfaces: (1) common procurement of wafers containing procedures
1.1.1.3	Pixel Electronics	8,500 good IC chips	1.1.2.1 20.5%	 1357	Deliverables :(1) Level-of-effort design and testing(approximately 50% of tota (3) funding of procurement of wafers that yield 8,500 good IC chips.
					Definition of interfaces: (1) design requirements and specifications; (2) testing procedures.
1.1.1.4	Pixel Hybrids	1,000	1.1.2.4 11%	 372	Deliverables :(1) Prototype(demonstrator) hybrid in Cu-on Kapton technology production disk module hybrids(1,000 good) and connecting cables up to disk
					Definition of interfaces: (1) Module Clock and Control chip to be provi provided by others, including all optical links.
1.1.1.5	Pixel Modules	1,000			Deliverables: (1) Level-of-effort for development of bump bonding ;(2) dumn level-of-funding contribution to bump bonding of modules; (4) testing of all di

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
					Definition of interfaces: (1) procurement of prototype and (2) producti
1.1.1.6	Pixel Common Items	Level-of-funding	1.1.3.3 16.3% 1.1.4 10%	284 10	Deliverables: (1) Level-of-funding contribution($200K FY97) to pixel commo Module 0
					Definition of interfaces: Common procurements.
1.1.2	Silicon Strip System				Deliverables (1): Integrated circuit(IC) electronics(about 50%);(2) design of b detectors for fabrication of 670 (delivered) modules in U.S.;(4) fabrication of r
					Definition of interfaces: (1) Design and common procurement of IC ele ATLAS
1.1.2.1	IC Electronics	30,420 chip sets or chips	1.2.2.1 50%	2945	Deliverables: (1) Level-of-effort design; (2)Funding for prototype chip orders equivalents.
					Definition of interfaces: (1) Design and common procurement.
1.1.2.2	Hybrids	727	1.2.3 15.8%	623	Deliverables:(1) Barrel module hybrid design and (2) hybrid components for a assembly
					Definition of interfaces: (1) Design review and agreement by ATLAS
1.1.2.3	Modules	670	1.2.4 15.2%	331	Deliverables: 670 barrel modules delivered to UK assembly site.
					Definition of interfaces: (1) Production process agreement within ATL ATLAS
1.1.3	ReadOut Drivers	345	1.1.3.2 100% 1.2.7 75%	560 1133	Deliverables: (1) Test beam support of SCT and pixels consisting of 50 DSP (preprototype RODs) and three iterations of pixel support cards and (2) 256 p RODs, along with prototypes necessary for the design of production units. Th
					Definition of interfaces: (1) Design agreement by non-U.S. ATLAS and the UK to be mounted on SCT ROD cards.
	Cable Extensions, Pixels		1.4.5.2 16%	16	

TRT 1.2

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
1.2.1	Barrel Mechanics				
1.2.1.1	Barrel Module	102	1.3.1.2 49% 1.3.1.4 94%	1185	Production and testing 100% of the barrel modules. 34 of each type including 2
					Some module components provided by non-U.S. ATLAS **Straws: From CERN. U.S. pays the cost** **Tension Plates: From Lund. U.S. does not pay the cost.**
1.2.1.1.	Cables		1.3.3.1 6%	90	Responsible for $60,000, cables.
1.2.1.2	Gas/Systems and Power Supplies		1.3.4.3 43%	447	Responsible for $300,000 of the production cost. U.S. is not responsible for th
1.2.1.3	Installation	Level of effort			Testing of the modules at CERN (100% U.S. responsibility), assembly of the n other TRT collaborators) and final installation in the experimental area (shared
1.2.5	Electronics				
1.2.5.1	ASDBLR	425,000 channels	1.3.2.1 57%	1698	100% of the ASDBLR for the entire TRT system..
1.2.5.2	DTMROC	Level of effort			Responsible for the design, and prototyping of receiver, driver and DAC sectio
1.2.5.3	PCB	106,000 channels	1.3.2.4 38%	121.6	Responsible for designing and prototyping of the endcap TRT front-end PCBs Responsible for 1/3 of the production and testing of endcap PCBs.
					DTMROC is provided by LUND.
1.2.5.4	Common Electronics		1.3.3.1 13%	195	Responsible for $164,000 of the common items, cables.
1.2.5.6	Installation*	Level of effort			Installation and testing of the TRT electronics with other TRT collaborators ..

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
1.3.1	Barrel Cryostat	1			Barrel Cryostat including: Rails for calorimeter, tracker; support and interface
					Definition of interfaces. ATLAS will take over once the cryostat is at C
1.3.2	Feedthrough				100% Signal, calibration and HV transfer feedthroughs for Barrel Cryostat.
1.3.2.1	Signal	3 - Test	2.9.2.4 50% 2.9.3.3 50% 2.9.3.6 100%	123 30 20	Three feedthrough assemblies for the test beam cryostat.
1.3.3	Cryogenics				At this moment the U.S. deliverables are not defined.
1.3.4	Readout Electrodes & Mother-boards				Contribution to the readout electrodes and the motherboards system for the Ba
1.3.4.1	Readout Electrodes	Level of Effort	2.2.2.4 and 2.4.2.5	2976	U.S. will participate in the design at a level of effort. R&D on large electrodes,
					Non-U.S. ATLAS is responsible for the procurement, testing of the read
1.3.4.2	Motherboards	100% EM Barrel	2.2.3.1 100%	1230	This include 100% of the summing boards (SB), alignment boards (AB), moth high voltage (HV) boards for the barrel EM calorimeter. We will deliver the n boards stated below + 5% which should cover any spoilage during installation.
1.3.4.2.3.1	Summing Boards	7168 224			SB for barrel EM. SB for module 0.
1.3.4.2.3.2	Motherboard	960 30			MB for barrel EM. MB for module 0.
1.3.4.2.3.3	Alignment Boards	960 30			AB for barrel EM AB for module 0.
1.3.4.2.3.4	HV Boards	498 14			HV Boards for Barrel EM HV boards for module 0
					Non-U.S. ATLAS will do the installation of the motherboard system on **level of effort help in the installation.** **Define Interfaces.**
1.3.5	Preamps and Calibration				
1.3.5.1	Preamps	 100hybrids 1000hybrids 28500hybrids	2.8.4.1 50%	833	Design and optimization of preamps for the EM and Forward calorimeters (10 Pre-prototype hybrids: 4 channels/hybrid Module 0 and assorted tests. Enough to equip the barrel EM and the Forward calorimeters.

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectation**
1.3.5.2	On Board Calibration	For 846 Boards	2.8.4.8		100% of the design, components for the on board calibration for EM and Forwa
1.3.5.3	Precision Calibration	Level of effort	2.8.4.8		Participate in the design of the precision calibration. Radiation tolerance studies.
1.3.6	System Crate				Design and specification for the System crate: 100% Barrel EM and Forward C accommodate also EndCap EM and Hadronic readouts. The physical deliverabl calorimeters. U.S. will play a major part in the installation of the system crates a
1.3.6.1	Pedestals	32 2 5	2.8.2.1		Barrel EM Forward Calorimeter Test Cryostats Barrel, End Cap and Forward.
1.3.6.2	Warm Cables & Base Plane	2400 Cab 64 BP	2.8.2.1		Module 0, Barrel, EM and Forward Barrel EM Forward.
1.3.6.3	Crates	5 32 2	2.8.2.1 59% 2.10.2.1 100%	 1644 545	Barrel EM Forward Module 0, Barrel, EM and Forward .
1.3.6.4	Power Supplies	For 34 Crates +5	2.8.2.2 59%	 1434 40	Barrel EM Forward Module 0, Barrel, EM and Forward, Barrel EM, Forward.
1.3.6.5	Cooling	For 34 Crates +5	2.8.2.1 59%		Cooling includes the manifolds on the crates, as well as the radiators attached to the front end boards for the Barrel EM and Forward. Module 0, Barrel, EC and Forward .
1.3.6.5.4					ATLAS will help in the installation, integration of the system and supply of wat
1.3.7	FEB				Include the Front End Boards (FEB). This include all design , prototype, assembly, testing and installation of the boards.
1.3.7.1.2.1	Analog FEB Boards	4			Design and deliver analog boards for test beams.
1.3.7.1.2.2	FEB Boards for Module 0	40	2.10.4.1 68%	401	Deliver 5000 channels equivalent of FEB.
					Expect shapers and controllers to come from non-U.S. ATLAS Collabora
1.3.7.1.3	FEB	832 EM 14 For. 846 Tot.	2.8.4.7 2.8.4.8 2.8.4.9 59%	3008	U.S. will deliver enough FEB for the EM barrel and the forward calorimeter.

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectation**
1.3.7.2	SCA	120,000 channels	2.8.4.5 59%	1248	Switch Capacitor Array (SCA) Shared design and production with Orsay/Sacla U.S. part is 120K channels. **DMILL design by Orsay/ Saclay** - share producti
1.3.7.4	Links to ROD	846 Cards	2.8.7.1 35%	396	Links to ROD including the fiber and transmitter.
1.3.8	Level I Trigger Interface				Includes Layer Sums, and Level I interface in the counting room. Design, prototype, production and installation.
1.3.8.1	Layer Sums	3441 Boards	2.8.4.4 100%	350	Layer Sums for the EM and Forward calorimeter. Both for Module 0 and for final ATLAS experiment.
1.3.8.2	Level I interface	192 Boards	2.8.5.2 100%	490	Interface for Level I for the EM and Forward calorimeters.
1.3.9	ROD			205	Readout Drivers (RODs) and Mapping Boards for the equivalent of the EM ba
1.3.9.1	ROD Boards	10Proto. 500Final	2.8.7.3 30% 2.10.7.2 20%	965 43	ROD Boards for the Barrel EM Calorimeter. Covers about 50% of the Barrel E
1.3.9.2	Remapping Boards	10Proto. 125Final	2.8.7.3	*	Remapping boards for the Barrel EM Calorimeter. Covers about 50% of the Ba *In appendix 3 there is an entry "241", 43.
1.3.10.1	Forward Calorimeter.	2	2.7.1.1	465	EM Section of the Forward Calorimeter -
1.3.10.2		2	2.7.2.1 100% 2.7.3.1 25% 2.7.3.2 100%	310 120 35	Cold electronics, cables, Motherboards, decoupling capacitors for the full Forwa Shipping Tools for assembly.

Tile Calorimeter 1.4

WBS #	Task	Quantity			Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
1.4.1.1.1 1.4.1.2.1 1.4.1.2.4 1.4.1.3.1	Submodule design Module design Module Installation Fixt. & Tool. design	3.3 FTEyr			Mechanical Design (level of effort)

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectation**
1.4.1.1.2 1.4.1.2.2	Submodule prot. Module prot.				All master plate stamping, four submodules and instrumentation effort for Barre All master plate stamping for two Extended Barrel Module 0s Mechanical and optical assembly of one Extended Barrel Module 0
1.4.1.1.3. 2.1-3	Master plates	37,225 plates **102,355** **166 kCHF**	3.1.1 29% 3.1.2.2 100%	680 210	Master plates for two Extended Barrel Calorimeters, including purchase of sheet **Spacer plates for one extended barrel calorimeter - supplied by non-U.S.** **Financial contribution toward extended barrel master plates - supplied b**
1.4.1.1.3. 2.3	Master pl ship	18,610	3.1.3.2 50%	463	Master plates shipped to Barcelona for EB production
1.4.1.3 1.4.2.3	Fixtures and tooling		3.1.4 22%	112	Tooling for submodule and module assembly
1.4.1.1.3 1.4.1.2.3 1.4.2.2.3	Submod prod Mod. prod.	64 mods **236,000** **18,610** **2**	3.1.6.2 100% 3.1.7 14%	 210 21	Mechanical and optical assembly of 576 submodules for 64 modules for one Ex **Scintillator tiles, installed inTyvek wrappers** **Wavelength-shifting fiber installed in guide profiles for one extended ba** **Two facing machines for fiber bundle optical couplers**
1.4.1.4	Module testing	64 **2**			Testing of 64 assembled modules with Cs sources **Two drawer assemblies with readout electronics for module testing**
1.4.1.2.3. 3.3	Ship to CERN	64			Shipping of 64 modules to CERN
1.4.2.1.1 1.4.2.2.1	EB Scint. design EB Fiber design	0.4 FTEyr			Optics R&D (level of effort)
1.4.2.1.3.1	Scint. wrappers	472,000	3.2.6 100%	100	Tyvek wrappers for all scintillator tiles for the Barrel and two Extended Barrel c
1.4.3.2. 1-2	FE Elect des/prot				Design of the front-end 3-in-1 card (Lead, shared with Stockholm and Barcelona
1.4.3.4. 1-2	Dig Elect des/prot				Design of links of digitizing electronics to TTC and Detector Control Systems
1.4.3.4. 1-2	Dig Elect des/prot	0.7 FTEyr			Other design of digitizing electronics (level of effort)
1.4.3.1 1.4.4.1.3.6	PMT block	3,328 **3,328 se**ts	3.3.2 33% 3.3.3 25%	 920 9	photomultiplier tubes, tested and assembled in PMT blocks **Non-PMT Parts for PMT block assembly**
1.4.3.2.3	FE Prod	10,020 ch	3.3.5 88%	598	88% Module 0 PMTs front end electronics procurement (plus contribution from design)

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectation**
1.4.3.5.3	System control	1 module			VME Control module
1.4.4.1	Gap submods	128	3.1.6.4 100%	60	ITC Plug special submodules for both Extended Barrel Calorimeters, with end p
1.4.4.2	Cryostat scint.	140 each assy	100%	0	ITC Plug and cryostat scintillator assemblies for both Extended Barrel Calorime

Muon 1.5

WBS #	Task	Quantity	MoU ref.#	CORE value	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectation f**
1.5.1.4	MDT Chambers	320	4.1.2.1 to 4.1.2.6 100%	3630	Complete Monitored Drift Tube Chambers including the in-plane alignment syste 105,472 (+5% wastage). Required number of endplugs (210,944+5%) to be prov
1.5.1.5	MDT Installation		4.5.1.5 25%	600	Contribution limited to level of effort.
1.5.2.2.1	MDT Kinematic Mounts	168 sets			Design, development and fabrication of 168 sets of kinematic mounts required for chambers.
1.5.2.2.2	MDT Chamber Connectors	384			Design, development and fabrication of 384 chamber connectors.
1.5.3.3.1.1	Hedgehog PC Boards	4400			Design, development and fabrication of 4400 Hedgehog printed circuit boards ne constructed by the U.S. groups.
1.5.3.3.1.2	Mezzanine PC Boards	15,479	4.1.3.1 100%	2435	Design, development and fabrication of 15479 Mezzanine PC boards required for required TDC chips will be provided by the Japanese groups.
1.5.3.3.1.3	Signal Patch Panels	640			Design, development and fabrication of 640 signal patch panels required for the U
1.5.3.3.1.5	High Voltage Patch Panels	640			Design, development and fabrication of 640 HV patch panels required for the U.S
1.5.3.3.1.6	Additional ASD ASIC	19387			An additional 19387 IC's will be fabricated (about 20% above what is needed) to

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
1.5.4.4.1	CSC1	32	4.2.1 46%	129	Design, development and fabrication of 32 CSC Modules of Design 1.
1.5.4.4.2	CSC2	32	4.2.1 46%		Design, development and fabrication of 32 CSC Modules of Design 2.
1.5.4.4.3	Installation		4.5.1.6 41%	33	Installation/commissioning at CERN will be limited to level of effort.
1.5.5.4.1.1	ASM Boards	1280	4.2.3 97% ...		Design, development and fabrication of 1280 PC Boards required for fully equ
1.5.5.4.1.2	DCC Boards	64	4.2.3 97%...	total 1370	Design, development and fabrication 64 Data Collection and Control boards.
1.5.5.4.1.3	HV Boards	64	4.2.3 97%...		Design, development and fabrication 64 Data High Voltage boards.
1.5.5.4.2.1	Readout Drivers (ROD)	8	4.2.3 97%...		Design, development and fabrication 8 Data Readout Driver modules.
1.5.5.4.2.2	DCS Modules	2	4.2.3 97%...		Design, development and fabrication 2 Detector Control Modules.
1.5.5.4.2.3	TTC Modules	2	4.2.3 97%...		Design, development and fabrication 2 Trigger/Timing/Calibration Modules.
1.5.5.4.2.4	VME Crates	2	4.2.3 97%...		Provide the 2 VME crates with their controllers needed for the CSC off-chamb
1.5.6.3.1	Alignment Bars	80	4.5.1.2 47%	542	Provide the 80 Alignment bars needed for the Forward Alignment System.
1.5.6.3.2	Three-point Systems	1504	4.5.1.2 100%		Provide 1504 three-point systems for the Forward Alignment System.
1.5.6.3.3	Multipoint Systems	2144	4.5.1.2 28%		**Provide 2144 multi-point systems for the Forward Alignment System. T item are to be provided by the Max Planck Institute.**
1.5.6.4	Installation				Installation at CERN limited to level of effort.

Trigger and Data Acquisition 1.6

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
1.6.1	LVL2 Supervisor & RoI Builder	1	5.2.1.5 100%	845	100% of design, development, procurement, fabrication, and installation.

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
					Design will be compatible with chosen level 2 architecture.
1.6.2	LVL2 Calorim. Trigger		5.2.1.1 45.5%	851	Contribution to the LVL2 Calorimeter Trigger. This contribution is targeted tc required for design, development, procurement, fabrication, and installation.
					ATLAS collaborators will provide the remaining 50% of the effort and
1.6.2.1	Design	Level of Effort			U.S. will participate in design of LVL2 Calorimeter Trigger at a level of effort required.
1.6.2.2	Development & Prototypes	Level of Effort			U.S. will participate in development and prototyping of LVL2 Calorimeter Trig the total effort required. U.S. will also provide a portion of the equipment requ
1.6.2.3	Production		5.2.1.3 28.4%	1305	Contribution to production of LVL2 Calorimeter Trigger. This contribution is materials required to produce the final trigger.
1.6.2.3.1	Production EDIA	Level of Effort			U.S. will participate in procurement and fabrication of LVL2 Calorimeter Trig the total effort required.
1.6.2.3.2	Production Equipment	Level of Effort			U.S. will provide 1025 FY97 K$ for procurement of equipment for the produc Readout Buffers.
1.6.2.4	Install & Commission	Level of Effort			U.S. will participate in installation and commissioning of LVL2 Calorimeter T of the total effort required.
1.6.3	LVL2 SCT Trigger				Contribution to the LVL2 SCT Trigger. This contribution is targeted to provic design, development, procurement, fabrication, and installation.
					Non-U.S. ATLAS collaborators will provide the remaining 50% of the e
1.6.3.1	Design	Level of Effort			U.S. will participate in design of LVL2 SCT Trigger at a level of effort estimat design.
1.6.3.2	Development & Prototypes	Level of Effort			U.S. will participate in development and prototyping of LVL2 SCT Trigger at total effort required. U.S. will also provide a portion of the equipment requirec
1.6.3.3	Production				Contribution to production of LVL2 SCT Trigger. This contribution is targete required to produce the final trigger.
1.6.3.3.1	Production EDIA	Level of Effort			U.S. will participate in procurement and fabrication of LVL2 SCT Trigger at a effort required.
1.6.3.3.2	Production Equipment	Level of Effort			U.S. will provide 1205 FY97 K$ for procurement of equipment for the produc Readout Buffers.
1.6.3.4	Install & Commission	Level of Effort			U.S. will participate in installation and commissioning of LVL2 SCT Trigger a total effort required.

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
1.6.4	Architectural Design & LVL2 Global Trigger		5.2.1.4 18.2%	289	Contribution to the overall architectural design and development of the LVL2 procurement and fabrication of the LVL2 Global Trigger.
					Non-U.S. ATLAS collaborators will provide the remaining effort and m
1.6.4.1	Architectural Design	Level of Effort			U.S. will participate in overall architectural design of LVL2 Trigger System at
1.6.4.2	LVL2 Global Trigger Production	Level of Effort			U.S. will provide 232 FY97 K$ for procurement of equipment for the producti targeted to provide 25% of the equipment required.
1.6.5	T/DAQ Common Projects	Level of Effort			U.S. will provide 5967 FY97 k$ for procurement of T/DAQ equipment which U.S. will provide associated procurement effort.

Appendix 3: Initial Approved Scope of U.S. Deliverables

Silicon 1.1

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
					Definition of interfaces: (1) procurement of prototype and (2) producti
					Definition of interfaces: Common procurements.
1.1.2	Silicon Strip System				Deliverables (1): Integrated circuit(IC) electronics(about 50%);(2) design of b detectors for fabrication of 670 (delivered) modules in U.S.;(4) fabrication of r
					Definition of interfaces: (1) Design and common procurement of IC ele ATLAS
1.1.2.1	IC Electronics	18,252 chip sets or chips	1.2.2.1 30%	1767	Deliverables: (1) Level-of-effort design; (2) Funding for prototype chip orders equivalents.
					Definition of interfaces: (1) Design and common procurement.
1.1.2.2	Hybrids	727	1.2.3 15.8%	623	Deliverables:(1) Barrel module hybrid design and (2) hybrid components for a assembly
					Definition of interfaces: (1) Design review and agreement by ATLAS
1.1.2.3	Modules	670	1.2.4 15.2%	331	Deliverables: 670 barrel modules delivered to UK assembly site.
					Definition of interfaces: (1) Production process agreement within ATL ATLAS
1.1.3	ReadOut Drivers	193	1.1.3.2 100% 1.2.7 75%	947	Deliverables :(1) Test beam support of SCT and pixels consisting of 50 DSP (preprototype RODs) and three iterations of pixel support cards and (2) 256 p RODs, along with prototypes necessary for the design of production units. Th Initial scope is 50% of total.
					Definition of interfaces: (1) Design agreement by non-U.S. ATLAS and from the UK to be mounted on SCT ROD cards.

TRT 1.2

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
1.2.1	Barrel Mechanics				
1.2.1.1	Barrel Module	71	1.3.1.2 49% 1.3.1.4 94%	825	Production and testing 100% of the barrel modules. 34 of each type including 2 Initial scope is 70% of total.
					Some module components provided by non-U.S. ATLAS **Straws: From CERN. U.S. pays the cost** **Tension Plates: From Lund. U.S. does not pay the cost.**
1.2.1.1.	Cables		1.3.3.1 6%	90	Responsible for $60,000 of the cables.
1.2.5	Electronics				
1.2.5.1	ASDBLR	276,250 channels	1.3.2.1	1104	100% of the ASDBLR for the entire TRT system. Initial scope is 65% of total.
1.2.5.2	DTMROC	Level of effort			Responsible for the design, and prototyping of receiver, driver and DAC sectic
1.2.5.3	PCB	106,000 channels	1.3.2.4 38%	122	Responsible for designing and prototyping of the endcap TRT front-end PCBs Responsible for 1/3 of the production and testing of endcap PCBs.
					DTMROC is provided by LUND.
1.2.5.4	Common Electronics		1.3.3.1 13%	195	Responsible for $164,000 of the common items, cables.
1.2.5.6	Installation	Level of effort			Installation and testing of the TRT electronics with other TRT collaborators. Initial scope is 65% of total.

Liquid Argon 1.3

WBS #	Task	Quantity			Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
1.3.1	Barrel Cryostat	1			Barrel Cryostat including: Rails for calorimeter, tracker; support and interface
					Definition of interfaces. ATLAS will take over once the cryostat is at CERN.
1.3.2	Feedthrough				100% Signal, calibration and HV transfer feedthroughs for Barrel Cryostat.
1.3.2.1	Signal	3 - Test			Three feedthrough assemblies for the test beam cryostat.

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
		68-Final			Need 64 full assemblies for the barrel cryostat. We will supply the components feedthroughs will be fully tested before and after installation.
					Interfaces, participate in the installation, machine components for the test beam **Pigtails - we will need enough pigtails + spares - amount depending on t** **during tests and installation.(Not less than 68+5% for spoilage)**
1.3.2.2	HV	6 - Final			HV feedthroughs for barrel and endcap ~800 channels per feedthrough
					Feedthrough will end on one side with bare cable and on the other side at the de ATLAS will help in the installation and the routing of cables.
1.3.3	Cryogenics				At this moment the U.S. deliverables are not defined.
1.3.4	Readout Electrodes & Mother-boards				Contribution to the readout electrodes and the motherboards system for the Bar
1.3.4.1	Readout Electrodes	Level of Effort	2.2.2.4 and 2.4.2.5 100%	1500	U.S. will participate in the design at a level of effort. R&D on large electrodes, Initial scope is 48% of total.
					Non-U.S. ATLAS is responsible for the procurement, testing of the read
1.3.4.2	Motherboards	100% EM Barrel	2.2.3.1 100%	1230	This include 100% of the summing boards (SB), alignment boards (AB), moth high voltage (HV) boards for the barrel EM calorimeter. We will deliver the n boards stated below + 5% which should cover any spoilage during installation.
1.3.4.2.3.1	Summing Boards	7168 224			SB for barrel EM. SB for module 0.
1.3.4.2.3.2	Motherboard	960 30			MB for barrel EM. MB for module 0.
1.3.4.2.3.3	Alignment Boards	960 30			AB for barrel EM AB for module 0.
1.3.4.2.3.4	HV Boards	498 14			HV Boards for Barrel EM HV boards for module 0
					Non-U.S. ATLAS will do the installation of the motherboard system on t **level of effort help in the installation.** **Define Interfaces.**
1.3.5	Preamps and Calibration				
1.3.5.1	Preamps	 100hy. 1000hy. 28500hy.	2.8.4.1 50%	833	Design and optimization of preamps for the EM and Forward calorimeters (10 Pre-prototype hybrids (hy): 4 channels/hybrid Module 0 and assorted tests. Enough to equip the barrel EM and the Forward calorimeters.

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectation**
1.3.5.2	On Board Calibration	For 846 Boards	2.8.4.8 100%		100% of the design, components for the on board calibration for EM and Forwa
1.3.5.3	Precision Calibration	Level of effort	2.8.4.8 100%		Participate in the design of the precision calibration. Radiation tolerance studies.
1.3.6	System Crate				Design and specification for the System crate: 100% Barrel EM and Forward C accommodate also EndCap EM and Hadronic readouts. The physical deliverabl calorimeters. U.S. will play a major part in the installation of the system crates a
1.3.6.1	Pedestals	32 2 5	2.8.2.1 59%		Barrel EM Forward Calorimeter Test Cryostats Barrel, End Cap and Forward.
1.3.6.2	Warm Cables & Base Plane	2400 Cab 64 BP	2.8.2.1 59%		Module 0, Barrel, EM and Forward Barrel EM Forward.
1.3.6.3	Crates	5 32 2	2.8.2.1 59% 2.10.2.1 100%	1664 545	Module 0, Barrel, EM and Forward Barrel EM Forward.
1.3.6.4	Power Supplies	For 14 Crates	2.8.2.2 59%	 529	Barrel EM Initial scope is for 36% of total. Forward Module 0, Barrel, EM and Forward, Barrel EM, Forward.
1.3.6.5	Cooling	For 14 Crates +5	2.8.2.1 59%		Cooling includes the manifolds on the crates, as well as the radiators attached to the front end boards for the Barrel EM and Forward. Module 0, Barrel, EC and Forward.
1.3.6.5.4					ATLAS will help in the installation, integration of the system and supply of wat
1.3.7	FEB				Include the Front End Boards (FEB). This include all design , prototype, assembly, testing and installation of the boards.
1.3.7.1.2.1	Analog FEB Boards	4			Design and deliver analog boards for test beams.
1.3.7.1.2.2	FEB Boards for Module 0	40	2.10.4.1 68%	401	Deliver 5000 channels equivalent of FEB.
					Expect shapers and controllers to come from non-U.S. ATLAS Collabora

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectation**
1.3.7.1.3	FEB	663 EM 14 For. 677 Tot.	2.8.4.7 2.8.4.8 2.8.4.9 59%	2407	U.S. will deliver enough FEB for the EM barrel and the forward calorimeter. Initial scope is for 80% of total.
1.3.7.2	SCA	96,000	2.8.4.5 59%	998	Switch Capacitor Array (SCA). Shared design and production with Orsay/Sacla U.S. part is 120K channels. Initial scope is 80% of total.
1.3.8	Level I Trigger Interface				Includes Layer Sums, and Level I interface in the counting room. Design, prototype, production and installation.
1.3.8.1	Layer Sums	3441 Boards	2.8.4.4 100%	350	Layer Sums for the EM and Forward calorimeter. Both for Module 0 and for final ATLAS experiment.
1.3.8.2	Level I interface	192 Boards	2.8.5.2 100%	490	Interface for Level I for the EM and Forward calorimeters.
1.3.9	ROD			205	Readout Drivers (RODs) and Mapping Boards for the equivalent of the EM bar
1.3.9.2	Remapping Boards	10Proto. 125Final	2.8.7.3 30% 2.10.7.2 20%	241 43	Remapping boards for the Barrel EM Calorimeter. Covers about 50% of the Ba
1.3.10	Forward Calorim.				
1.3.10.1		2	2.7.1.1	465	EM Section of the Forward Calorimeter -
1.3.10.2		2	2.7.2.1	310	Cold electronics, cables, Motherboards, decoupling capacitors for the full Forwa
1.3.10.2			2.7.3.1 25% 2.7.3.2	120 35	Shipping Tools for assembly

Tile Calorimeter 1.4

WBS #	Task	Quantity			Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
1.4.1.1.1 1.4.1.2.1 1.4.1.2.4 1.4.1.3.1	Submodule design Module design Module Installation Fixt. & Tool. design	3.3 FTEyr			Mechanical Design (level of effort)

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectati**
1.4.1.1.2 1.4.1.2.2	Submodule prot. Module prot.				All master plate stamping, four submodules and instrumentation effort for Ba All master plate stamping for two Extended Barrel Module 0s Mechanical and optical assembly of one Extended Barrel Module 0
1.4.1.1.3. 2.1-3	Master plates	37,225 plates **62,437** **101 kCHF**	3.1.1 29% 3.1.2.2 100%	680 210	Master plates for two Extended Barrel Calorimeters, including purchase of sh **Initial scope is 61% of total.** **Spacer plates for one extended barrel calorimeter - supplied by non-U.** **Financial contribution toward extended barrel master plates - supplie** **63% of total.**
1.4.1.1.3.2.3	Master pl ship	18,610	3.1.3.2 50%	463	Master plates shipped to Barcelona for EB production
1.4.1.3 1.4.2.3	Fixtures and tooling		3.1.4 22%	112	Tooling for submodule and module assembly
1.4.1.1.3 1.4.1.2.3 1.4.2.2.3	Submod prod Mod. prod.	45/40 **236,000** **18,610** **2**	3.1.6.2 100% 3.1.7 14%	131 21	Mechanical and optical assembly of 45 submodules and 40 complete modules scope is 71% of total. **Scintillator tiles, installed inTyvek wrappers** **Wavelength-shifting fiber installed in guide profiles for one extended** **Two facing machines for fiber bundle optical couplers**
1.4.1.4	Module testing	40 **2**			Testing of assembled modules with Cs sources **Two drawer assemblies with readout electronics for module testing**
1.4.1.2.3.3.3	Ship to CERN	64			Shipping of 64 modules or components to CERN. Initial scope is 63% of tot
1.4.2.1.1 1.4.2.2.1	EB Scint. design EB Fiber design	0.4 FTEyr			Optics R&D (level of effort)
1.4.2.1.3.1	Scint. wrappers	472,000	3.2.6 100%	100	Tyvek wrappers for all scintillator tiles for the Barrel and two Extended Barre
1.4.3.2. 1-2	FE Elect des/prot				Design of the front-end 3-in-1 card (Lead, shared with Stockholm and Barcel
1.4.3.4. 1-2	Dig Elect des/prot				Design of links of digitizing electronics to TTC and Detector Control System
1.4.3.4. 1-2	Dig Elect des/prot	0.7 FTEyr			Other design of digitizing electronics (level of effort)
1.4.3.1 1.4.4.1.3.6	PMT block	**2400** **2400 sets**	3.3.2 3.3.3	464	photomultiplier tubes, tested and assembled in PMT blocks **Non-PMT Parts for PMT block assembly** Initial scope is 72% of total.

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectation f**
1.4.3.2.3	FE Prod	10,020 ch	3.3.5 88%	598	44% of front end electronics procurement (jointly with Stockholm plus contributi final design)
1.4.3.5.3	System control	1 module			VME Control module
1.4.4.1	Gap submods	77	3.1.6.4 100%	36	ITC Plug special submodules for both Extended Barrel Calorimeters, with end pla Initial scope reduced to 60%.

Muon 1.5

WBS #	Task	Quantity	MoU ref.#	CORE value	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectation f**
1.5.1.4	MDT Chambers	240	4.1.2.1 to 4.1.2.6 100%	2723	Complete Monitored Drift Tube Chambers including the in-plane alignment syste 105,472 (+5% wastage). Required number of endplugs (210,944+5%) to be prov Initial scope reduced to 64%.
1.5.1.5	MDT Installation		4.5.1.5 25%	600	Contribution limited to level of effort.
1.5.2.2.1	MDT Kinematic Mounts	126 sets			Design, development and fabrication of 168 sets of kinematic mounts required for chambers.
1.5.2.2.2	MDT Chamber Connectors	288			Design, development and fabrication of 384 chamber connectors.
1.5.3.3.1.1	Hedgehog PC Boards	3212			Design, development and fabrication of 4400 Hedgehog printed circuit boards ne constructed by the U.S. groups.
1.5.3.3.1.2	Mezzanine PC Boards	14,291	4.1.3.1 92%	2248	Design, development and fabrication of 15479 Mezzanine PC boards required for required TDC chips will be provided by the Japanese groups. Initial production r
1.5.3.3.1.3	Signal Patch Panels	640			Design, development and fabrication of 640 signal patch panels required for the U
1.5.3.3.1.5	High Voltage Patch Panels	640			Design, development and fabrication of 640 HV patch panels required for the U.S
1.5.3.3.1.6	Additional ASD ASIC	19387			An additional 19387 IC's will be fabricated (about 20% above what is needed) to

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & **Expectatio**
1.5.4.4.1	CSC1	16	4.2.1	65	Design, development and fabrication of 32 CSC Modules of Design 1. Initial p
1.5.4.4.2	CSC2	16			Design, development and fabrication of 32 CSC Modules of Design 2. Initial
1.5.4.4.3	Installation		4.5.1.6 41%	16	Installation/commissioning at CERN will be limited to level of effort.
1.5.5.4.1.1	ASM Boards	640	4.2.3 97%	700	Design, development and fabrication of 640 PC Boards required for fully equi
1.5.5.4.1.2	DCC Boards	32	4.2.3 97%		Design, development and fabrication 32 Data Collection and Control boards.
1.5.5.4.1.3	HV Boards	32	4.2.3 97%		Design, development and fabrication 32 Data High Voltage boards.
1.5.5.4.2.1	Readout Drivers (ROD)	4	4.2.3 97%		Design, development and fabrication 4 Data Readout Driver modules.
1.5.5.4.2.2	DCS Modules	1	4.2.3 97%		Design, development and fabrication 1 Detector Control Modules.
1.5.5.4.2.3	TTC Modules	1	4.2.3 97%		Design, development and fabrication 1 Trigger/Timing/Calibration Modules.
1.5.5.4.2.4	VME Crates	1	4.2.3 97%		Provide the 1 VME crates with their controllers needed for the CSC off-chamb
1.5.6.3.1	Alignment Bars	40	4.5.1.2 50%	268	Provide the 40 Alignment bars needed for the Forward Alignment System.
1.5.6.3.2	Three-point Systems	1504	4.5.1.2 100%		Provide 1504 three-point systems for the Forward Alignment System.
1.5.6.4	Installation				Installation at CERN limited to level of effort.

Appendix 4: U.S. ATLAS Major Project Milestones (Level 1)

Description	Baseline Schedule	Forecast (F) Date	Actual (A) Date
Project Start	01-Oct-95	01-Oct-95 (F)	01-Oct-95 (A)
Project Completion	30-Sep-05	30-Sep-05 (F)	

Appendix 5: U.S. ATLAS Major Project Milestones (Level 2)

Subsystem	**Schedule Designator**	**Description**	**Baseline Schedule**	**Forecast (F) / Actual (A) Date**
Silicon (1.1)	SIL L2/1	Start Full Silicon Strip Electronics Production	30-Mar-01	30-Mar-01 (F)
	SIL L2/2	Start Full Strip Module Production	15-Oct-99	05-Jun-01 (F)
	SIL L2/3	ROD Design Complete	14-Apr-00	22-Nov-00 (F)
	SIL L2/4	Complete Shipment of Silicon Strip Module Production	08-Aug-03	26-Aug-03 (F)
	SIL L2/5	ROD Installation/Final Commissioning Complete	30-Sep-04	30-Sep-04 (F)
TRT (1.2)				
Mechanical	TRT L2/1	Final Design Complete	31-Dec-98	07-Dec-98 (A)
	TRT L2/2	Module Production Complete	29-Mar-02	03-Jun-02 (F)
	TRT L2/3	Barrel Construction Complete	31-Dec-02	31-Dec-02 (F)
Electrical	TRT L2/4	Select Final Elec Design	31-Jul-00	19-Jul-00 (F)
	TRT L2/5	Start Production of ASICS	31-Jul-00	10-Jan-01 (F)
	TRT L2/6	Installation Complete	30-Sep-04	30-Sep-04 (F)
LAr Cal (1.3)	LAr L2/1	Cryostat Contract Award	24-Jul-98	05-Aug-98(A)
	LAr L2/2	Barrel Feedthroughs Final Design Review	30-Sep-98	02-Oct-98 (A)
	LAr L2/3	Start Electronics Production (Preamps)	01-Jun-99	01-Nov-99 (F)
	LAr L2/4	FCAL Mechanical Design Complete	14-Dec-98	01-Apr-99 (F)
	LAr L2/5	FEB SCA Prod. Chip Submission/Contract Award	03-Jul-00	03-Jul-00 (F)
	LAr L2/6	Level 1 Trigger Final Design Complete	01-Mar-00	01-Mar-00 (F)
	LAr L2/7	ROD Final Design Complete	01-Jun-00	01-Jun-01 (F)
	LAr L2/8	Motherboard System Production Complete	01-Jan-01	01-Jun-01 (F)
	LAr L2/9	Cryostat Arrives at CERN	30-Mar-01	30-Mar-01 (F)
	LAr L2/10	Barrel Feedthroughs Production Complete	18-Jul-01	31-Jul-01 (F)
	LAr L2/11	FCAL-C Delivered to EC	03-Sep-01	03-Sep-01 (F)
	LAr L2/12	FCAL-A Delivered to EC	01-Nov-02	03-Mar-03 (F)

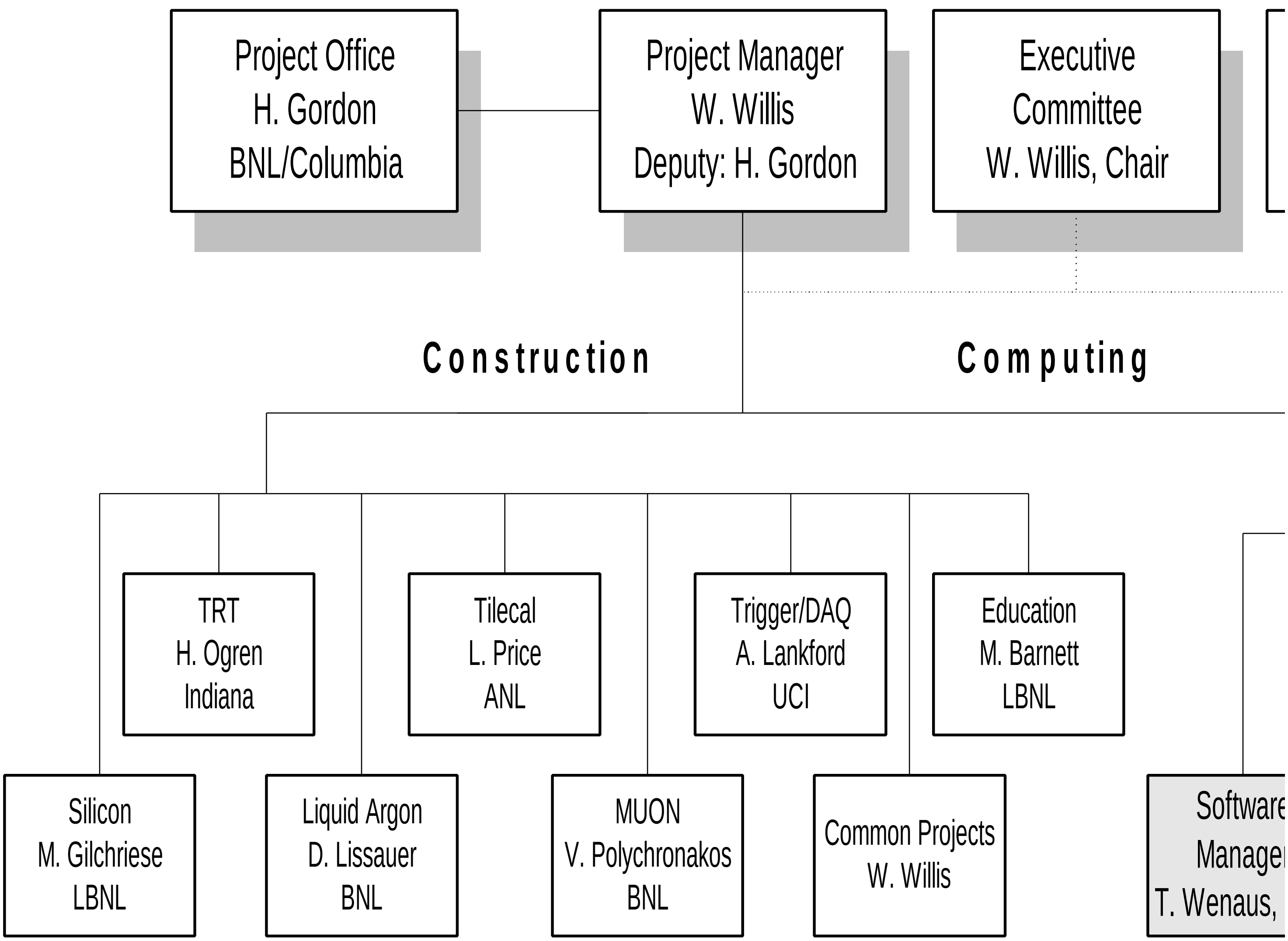
Subsystem	Schedule Designator	Description	Baseline Schedule	Forecast (F) / Actual (A) Date
Tile Cal (1.4)	Tile L2/1	Start Submodule Procurement	01-Sep-97	01-Sep-97 (A)
	Tile L2/2	Technology Choice for F/E Electronics	15-Nov-97	15-Nov-97 (A)
	Tile L2/3	Start Module Construction	01-May-99	01-May-99 (F)
	Tile L2/4	Start Production of Motherboards & Digitizer Boards	02-Jul-99	02-Jul-99 (F)
	Tile L2/5	Start Installation at CERN	01-Jun-02	01-Jun-02 (F)
	Tile L2/6	Module Construction Complete	01-Oct-02	10-May-02 (F)
	Tile L2/7	Installation at CERN Complete	01-May-04	01-May-04 (F)
Muon (1.5)	Muon L2/1	Start MDT Chambers Lines 1 and 3	04-Jan-99	13-Dec-99 (F)
	Muon L2/2	Start CSC Chamber Production	01-Jul-99	15-Nov-99 (F)
	Muon L2/3	ASD Chip Design Complete	29-Oct-99	29-Oct-99 (F)
	Muon L2/4	Final Design of Global Alignment Devices Complete	28-Apr-00	28-Apr-00 (F)
	Muon L2/5	CSC IC Production Complete	30-Jun-00	30-Jun-00 (F)
	Muon L2/6	Kinematic Mount Design Complete	30-Jan-01	30-Jan-01 (F)
	Muon L2/7	MDT Chambers (U.S.) Production Complete	30-Sep-03	23-Sep-04 (F)
	Muon L2/8	Kinematic Mount Production Complete	31-Dec-03	10-May-04 (F)
	Muon L2/9	ROD Production Complete	30-Jan-04	06-Jan-04 (F)
	Muon L2/10	MDT Off-Chamber Electronics Production Complete	28-May-04	06-Jan-04 (F)
	Muon L2/11	CSC Assembly/Testing at CERN Complete	31-Dec-04	17-Dec-04 (F)
	Muon L2/12	Global Alignment Final Assembly/Checkout Complete	31-Dec-04	31-Mar-05 (F)
Trigger/ DAQ (1.6)	TDAQ L2/1	Select Final LVL2 Architecture	31-Dec-99	31-Dec-99 (F)
	TDAQ L2/2	LVL2 Trigger Design Complete	31-Dec-01	31-Dec-01 (F)
	TDAQ L2/3	LVL2 Trigger Prototype Complete	31-Dec-01	30-Sep-01 (F)
	TDAQ L2/4	Start Production	08-Jan-02	08-Jan-02 (F)
	TDAQ L2/5	Start Installation & Commissioning	05-Mar-02	05-Mar-02 (F)
	TDAQ L2/6	Production Complete	31-Dec-04	29-Oct-04 (F)
	TDAQ L2/7	LVL2 Installation & Commissioning Complete	31-Dec-04	31-Dec-04 (F)

Appendix 6: U.S. ATLAS Major Project Milestones (Level 3)

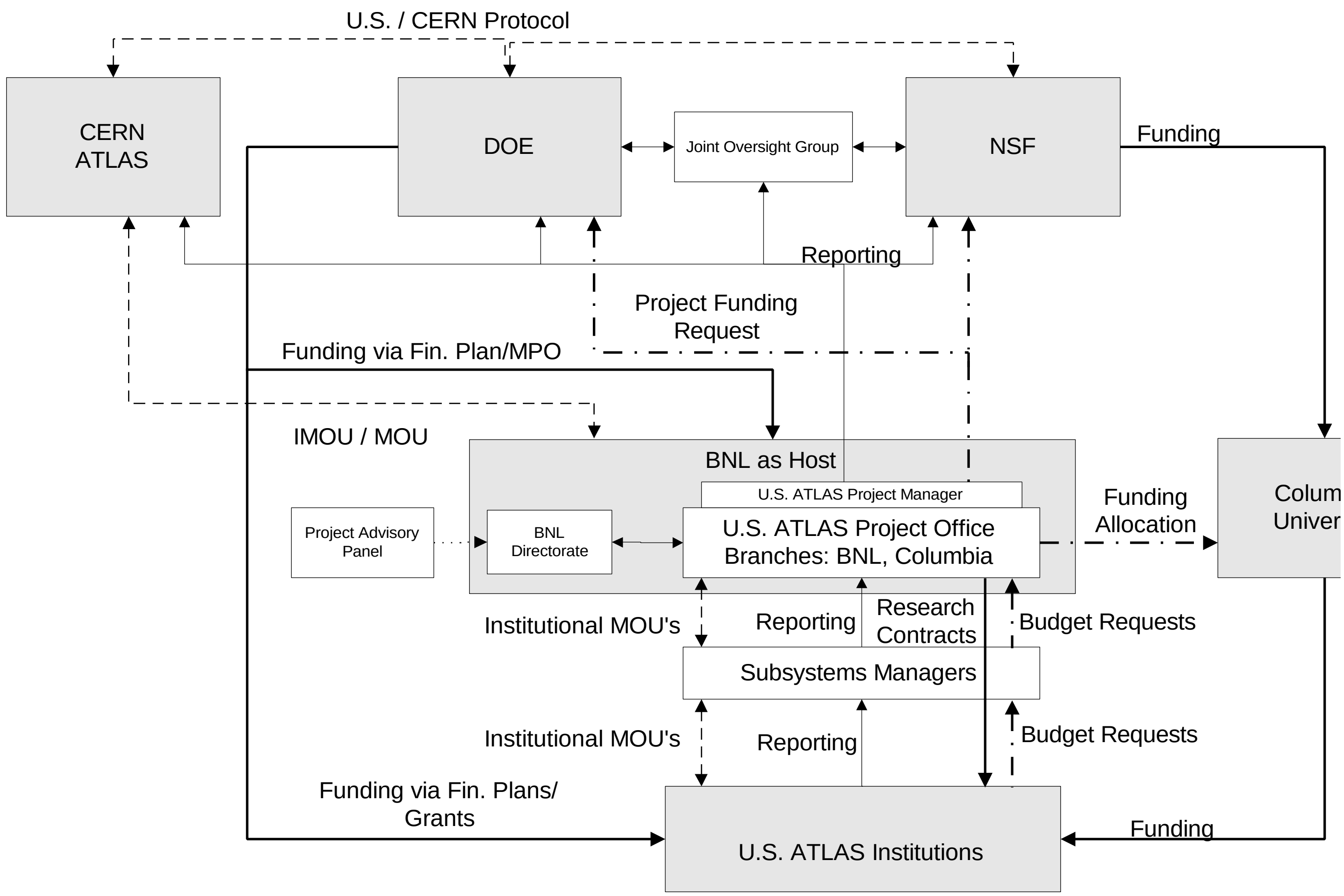
Subsystem	Schedule Designator	Description	Baseline Schedule	Forecast (F) / Actual (A) Date
Silicon (1.1)	SIL L3/1	Pixel System		
	SIL L3/2	Silicon Strip System	26-Aug-03	26-Aug-03 (F)
	SIL L3/3	Read-Out Drivers	01-Sep-03	01-Sep-03 (F)
TRT (1.2)				
Mechanical	TRT L3/1	Barrel Mechanics	30-Sep-04	30-Sep-04 (F)
Electrical	TRT L3/2	ASDBLR	27-Feb-02	27-Feb-02 (F)
	TRT L3/3	PCB-Endcap	18-Jun-03	18-Jun-03 (F)
LAr Cal	LAr L3/1	Barrel Cryostat	29-Mar-01	29-Mar-01 (F)
(1.3)	LAr L3/2	Signal Feedthroughs	31-Jul-01	31-Jul-01 (F)
	LAr L3/3	HV Feedthroughs	26-Jan-01	26-Jan-01 (F)
	LAr L3/4	Readout Electrodes	30-Jul-01	30-Jul-01 (F)
	LAr L3/5	Motherboard System	30-Oct-01	30-Oct-01 (F)
	LAr L3/6	Pedestal	03-Mar-01	03-Mar-01 (F)
	LAr L3/7	Cables/Base Plane	01-Aug-01	01-Aug-01 (F)
	LAr L3/8	Mechanical Crate	03-Jun-03	03-Jun-03 (F)
	LAr L3/9	Power Supplies	26-Feb-04	26-Feb-04 (F)
	LAr L3/10	Front End Boards	01-Jun-04	01-Jun-04 (F)
Off Detector Electronics				
	LAr L3/11	Level 1 Interface	01-Aug-03	01-Aug-03 (F)
	LAr L3/12	ROD System	31-Dec-04	31-Dec-04 (F)
FCAL				
Mechanical	LAr L3/13	FCAL Module	17-Dec-01	17-Dec-01 (F)
Tile Cal (1.4)				
	Tile L3/1	Submodules Completed	01-Oct-02	01-Oct-02 (F)
	Tile L3/2	Extended Barrel Module	04-Apr-03	04-Apr-03 (F)
	Tile L3/3	Extended Barrel Optics	01-Aug-02	01-Aug-02 (F)
	Tile L3/4	PMT Block	31-Dec-01	31-Dec-01 (F)
	Tile L3/5	Readout Electronics	31-Dec-01	31-Dec-01 (F)
Inter. Cal	Tile L3/6	Gap Submodules	15-Oct-02	15-Oct-02 (F)
	Tile L3/7	Cryostat Scintillators		

Subsystem	Schedule Designator	Description	Baseline Schedule	Forecast (F) / Actual (A) Date
Muon Spect. (1.5)	Muon L3/1	MDT Chambers	23-Sep-04	23-Sep-04 (F)
	Muon L3/2	MDT Supports	10-May-04	10-May-04 (F)
	Muon L3/3	Mezzanine ASD Card	01-Oct-03	01-Oct-03 (F)
	Muon L3/4	CSC Chambers	03-Dec-03	03-Dec-03 (F)
	Muon L3/5	CSC Electronics	02-Dec-03	02-Dec-03 (F)
	Muon L3/6	Off Det. Electronics	30-Apr-04	30-Apr-04 (F)
	Muon L3/7	Global Alignment	03-Jan-03	03-Jan-03 (F)
Trigger /DAQ (1.6)	TDAQ L3/1	LVL2SRB		
	TDAQ L3/2	LVL2 Cal TRG		
	TDAQ L3/3	LVL SCT TRG		
	TDAQ L3/4	Arch. & LVL2 Global Trg.		

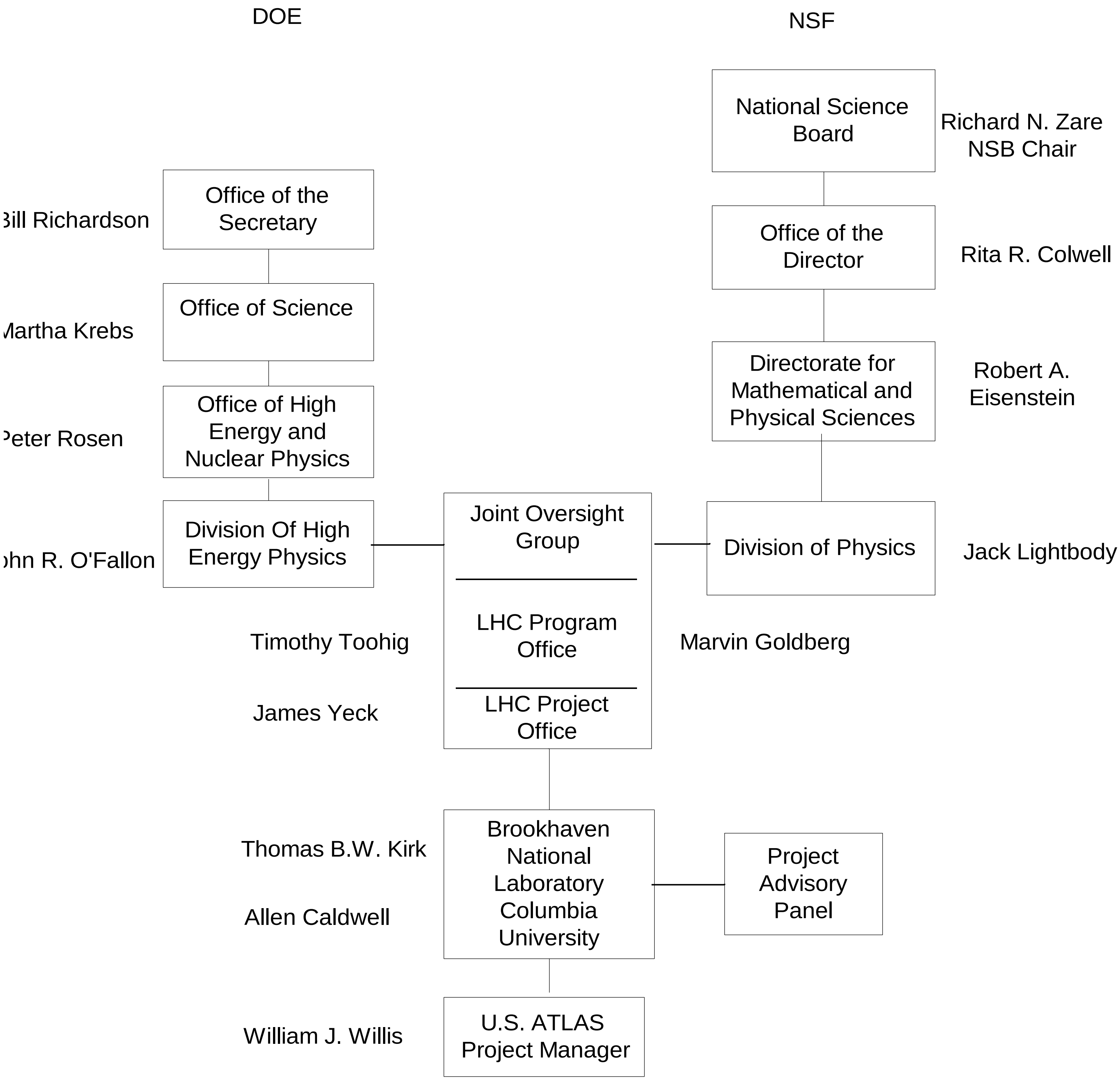
Apppendix 7-1: U.S. ATLAS Organization



Appendix 7-2: MOU, Funding and Reporting Process



Appendix 7-3: DOE-NSF-U.S. ATLAS Organization



Appendix 7-4: U.S. ATLAS Detector Institutional Responsibility by System

Subsystem	Institutions
Silicon	UC-Berkeley/LBNL, UC-Irvine, UC-Santa Cruz, Iowa State, New Mexico, Ohio State, Oklahoma, SUNY-Albany, Wisconsin
TRT	Duke, Hampton, Indiana, Michigan, Pennsylvania
Liquid Argon Calorimeter	Arizona, BNL, Columbia, Pittsburgh, Rochester, Southern Methodist U., SUNY-Stony Brook
Tile Calorimeter	ANL, Chicago, Illinois-Champaign/Urbana, Michigan State, UT-Arlington
Muon Spectrometer	Boston, BNL, Brandeis, Harvard, MIT, Michigan Northern Illinois, SUNY-Stony Brook, Tufts, UC-Irvine, Washington
Trigger and DAQ	ANL, UC-Irvine, Michigan State, Wisconsin
Common Projects	All institutions

Appendix 7-5: U.S. ATLAS Project WBS Index Cost Books

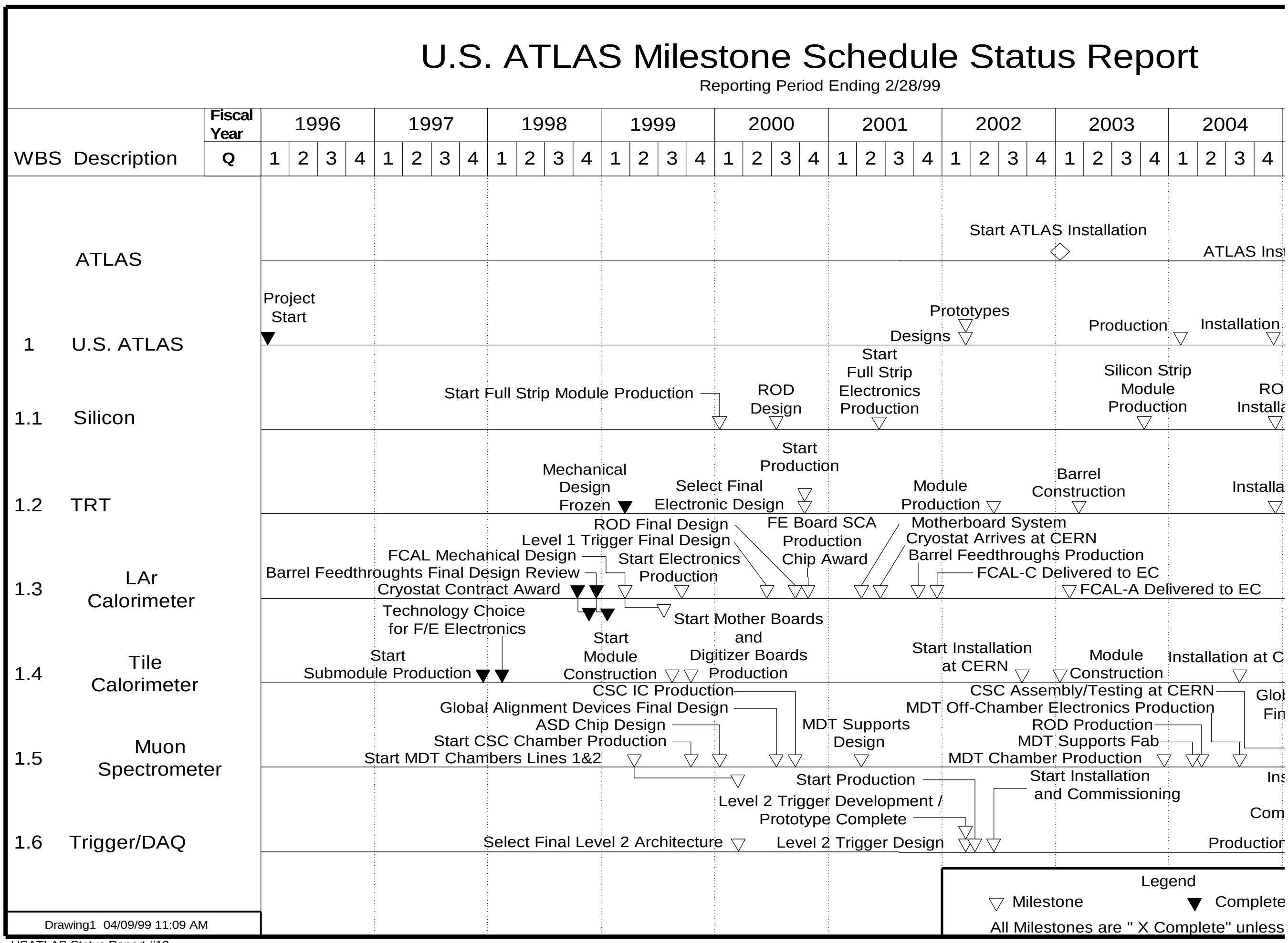
Level 1	Level 2	Level 3	WBS Title	Responsible Physicists	Responsible Engineer
1			U.S. ATLAS	W. Willis	N/A
	1.1		Silicon	M. Gilchriese	
		1.1.1	Pixel System	M. Gilchriese	
		1.1.2	Silicon Strip System	A. Seiden	
		1.1.3	Read-Out Drivers		R. Jared
	1.2		TRT	H. Ogren	
		1.2.1	Barrel Mechanics	H. Ogren	J. Callahan
		1.2.2	Barrel Structure	ATLAS	ATLAS
		1.2.3	Endcap Wheel	ATLAS	ATLAS
		1.2.4	Wheel Structure	ATLAS	ATLAS
		1.2.5	Electronics	H. Williams	R. VanBerg
	1.3		Liquid Argon Calorimeter	D. Lissauer	
		1.3.1	Barrel Cryostat	D. Lissauer	J. Sondericker
		1.3.2	Feedthroughs	D. Rahm	
		1.3.3	Cryogenics	D. Lissauer	J. Sondericker
		1.3.4	EM Electrodes/MB System	S. Rajagopalan	S. Rescia
		1.3.5	Preamp/Calibration	S. Rajagopalan	S. Rescia
		1.3.6	System Crate Integration	H. Takai	D. Makowiecki
		1.3.7	Front End Board	J. Parsons	W. Sippach
		1.3.8	Level 1 Trigger	W. Cleland	J. Rabel
		1.3.9	ROD System	W. Cleland	TBD
		1.3.10	Forward Calorimeter	J. Rutherfoord	L. Shaver
		1.3.11	Test Beams	M. Seman	N/A
	1.4		Tile Calorimeter	L. Price	
		1.4.1	Extended Barrel Mechanics	J. Proudfoot	V. Guarino
		1.4.2	Extended Barrel Optics	J. Huston	R. Richards
		1.4.3	Tile Cal Readout	J. Pilcher	H. Sanders
		1.4.4	Intermediate Tile Calorimeter	K. De	J. Li
	1.5		Muon Spectrometer	V. Polychronakos	
		1.5.1	MDT Chamber	F. Taylor	R. Coco
		1.5.2	MDT Supports	H. Lubatti	C. Daly
		1.5.3	MDT Electronics	J. Chapman	J. Oliver
		1.5.4	CSC Chambers	V. Tcherniatin	A. Gordeev
		1.5.5	CSC Electronics	V. Gratchev	P. O'Connor
		1.5.6	Global Alignment System	J. Bensinger	K. Hashemi
	1.6		Trigger/DAQ	A. Lankford	
		1.6.1	LVL 2 SRB	R. Blair	J. Dawson
		1.6.2	LVL 2 Calorimeter Trigger	M. Abolins	Y. Ermolin
		1.6.3	LVL 2 SCT Trigger	A. Lankford	R. Jared
		1.6.4	Architectural & Global Trigger	R. Blair	J. Dawson
		1.6.5	Common Projects	A. Lankford	
	1.7		Common Projects	W. Willis	N/A
		1.7.1	Total Equivalent Cash	W. Willis	N/A
		1.7.2	Total Institutional Dues	W. Willis	N/A
	1.8		Education	M. Barnett	N/A
	1.9		Project Management	H. Gordon	N/A
		1.9.1	DOE	H. Gordon	Kane/Premisler
		1.9.2	NSF	J. Dodd	N/A

Appendix 8-1: U.S. ATLAS Project Summary Cost Estimate

	U.S.ATLAS Project Summary Cost Estimate Presented in (AY$ × 1000)	
WBS No.	Description	Base Cost
	Technical Baseline	
1	U.S. ATLAS	
1.1	Silicon	8,424.5
1.2	TRT	8,187.1
1.3	LAr Calorimeter	35,240.8
1.4	Tile Calorimeter	6,842.8
1.5	Muon Spectrometer	19,835.0
1.7	Common Projects	9,179.1
1.8	Education	286.5
1.9	Project Management	7,338.9
	Subtotal	**95,334.7**
1.1.1	Pixel System Pre-Technical Baseline	2,284.7
1.6	Trigger/DAQ Pre-Technical Baseline	2,773.3
	Subtotal	**5,058.0**
	Management Contingency	**17,213.6**
	Contingency	**26,488.6**
	Subtotal	**43,702.2**
	Technical Baseline	**144,094.9**
Items Outside of Approved Technical Baseline		
1.1.1	Pixels	7,217.3
1.6	Trigger/DAQ	12,437.8
	Subtotal	**19,655.1**
	Total Project Cost	**163,750.0**

Includes cost changes for BCP 1-10, 12-14, 17 and 18.

Appendix 8-2: Master Milestone Schedule



USATLAS Status Report #12
Section 11

Appendix 8-3: U.S. ATLAS Funding Profile

(Presented in AY$ ´ 1,000)

FY	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
DOE Project	1,700	3,710	10,050	8,999	16,494	16,507	15,200	15,600	14,690	102,950
NSF Project				16,630	11,940	12,290	12,650	7,290		60,800
Total U.S. ATLAS	1,700	3,710	10,050	25,629	28,434	28,797	27,850	22,890	14,690	163,750

Appendix 9: U.S. ATLAS Construction Project Major Procurements

WBS	Component	Institution/ Resp. Person	Proj Cost (FY97 K$)	Design Reviews			PRR	Mgmt Cont Cost (FY97K$)	PM Approval	Bid Evaluation	
				Conceptual	Critical	Final				RFP Issued	Eval. Complete
1.1	**Silicon**										
1.1.2.1.2.1.1	Bipolar prototype fabs	UCSC/ Grillo	141	Complete	Complete	Complete		-	Complete	Complete	Complete
1.1.2.1.2.1.1	2nd Prototype fabs	UCSC/ Grillo	199	Complete	Complete	11-Dec-98		_	Complete	Complete	Complete
1.1.2.1.3.1.1	Bipolar production fab – Production	UCSC/ Grillo	872.2	Complete	10-Dec-99	3-Mar-00	2-Mar-01	686.6	15-Aug-00	1-Sep-00	19-Jan-01
1.1.2.1.3.2.1	CMOS production fab – Production	UCSC/ Grillo	1,158.5	Complete	10-Dec-99	3-Mar-00	2-Mar-01	686.5	15-Aug-00	1-Sep-00	19-Jan-01
1.1.2.2.3.1.1.2	Hybrid production printing	UCSC/ Haber	397	Complete	10-Dec-99	11-Feb-00	11-Apr-01	-	11-Oct-00	6-Dec-00	17-Jan-01
1.1.2.2.3.3.1	Fanout production printing	UCSC/ Haber	148	Complete	10-Dec-99	11-Feb-00	11-Apr-01	_	11-Oct-00	6-Dec-00	17-Jan-01
1.1.3.5.4	ROD 95% production	UW/ Jared	437	11-Jan-99	1-Oct-99	14-Mar-00	8-Nov-00	600.4	6-Jul-00	6-Oct-00	6-Dec-00
1.2	**TRT**										
1.2.1.1.3.1.1	Straws	Hampton/ McFarlane	113	Complete	Complete	08-Dec-98	7-Dec-98	_		3-Aug-98	5-Sep-98
1.2.1.1.3.1.3.2	Wire joint	Duke/ Oh	223	Complete	20-Sep-98	08-Dec-98	7-Dec-98	_	15-Apr-99	01-May-99	01-Jun-99
1.2.1.1.3.1.3.2	WireGuide	Indiana/ Ogren	172	Complete	20-Sep-98	08-Dec-98	7-Dec-98	_	07-Apr-99	15-Apr-99	01-May-99
1.2.1.1.3.1.6.1	Shell	Indiana/ Ogren	297	Complete	20-Sep-98	08-Dec-98	7-Dec-98	_	13-Dec-98	16-Sep-98	08-Dec-98
1.2.1.2	Gas/Cooling	Indiana/ Ogren	0	Complete	20-Sep-98	08-Dec-98	Part ordered by CERN	210			
1.2.5.1.3.2	ASDBLR Wafers	UPenn Williams	650	Complete		21-Jan-00	15-Jun-00	460	21-Jun-00	1-Jul-00	15-Oct-00
1.2.5.3.3	PCB(End Cap)	UPenn Williams	145	Complete		01-Oct-99	21-Feb-01	_	4-Mar-01	11-Mar-01	11-Jun-01

WBS	Component	Institution/ Resp. Person	Proj Cost (FY97 K$)	Design Reviews			PRR	Mgmt Cont Cost (FY97K$)	PM Approval	Bid Evaluation	
				Conceptual	Critical	Final				RFP Issued	Eval. Complete
1.3	**LAr Calor.**										
1.3.1	Barrel Cryostat	BNL/ Sondericker	3,754	17-Feb-97	28-Nov-97	2-Jan-98	9-Mar-98	_	15-Mar-98	1-Apr-98	3-Jul-98
1.3.2.1.3.1.1/2 .1	Pin Carriers	BNL/ Rahm	1,189	7-Feb-97	28-Nov-97	2-Oct-98	1-Feb-99	_	1-Dec-98	1-Dec-98	1-Feb-99
1.3.2.1.3.6.1	Vacuum Cables	BNL/ Rahm	742	7-Feb-97	28-Nov-97	2-Oct-98	1-Feb-99	_	1-Dec-98	1-Dec-98	1-Feb-99
1.3.4.1.3.1	Industrial Purchase (MB)	BNL/ Srini	985	3-Jan-96	23-Nov-98	1-Mar-00	1-Jun-00	985	07-Mar-00	15-Mar-00	01-Jun-00
1.3.4.2.3.2	Motherboards Front & Back	BNL/ Srini	130.5	1-May-96	13-Nov-98	15-Apr-99	1-Jun-99	_	30-Mar-99	01-Jun-99	1-Jul-99
1.3.5.1.3.1.2.1	Preamp Components	BNL/ Citterio	271	31-Dec-96	1-Jul-97	15-Jun-99	1-Aug-99	_	18-Jun-99	01-Jul-99	1-Aug-99
1.3.5.1.3.1.2.2	Preamp Assembly	BNL/ Citterio	866.4	31-Dec-96	1-Jul-97	15-Jun-99	1-Aug-99	_	18-Jun-99	01-Jul-99	1-Aug-99
1.3.6.2.3.1	Warm Cables	BNL/ Takai	679.5	2-Jun-97	3-May-99	3-May-99	1-Jun-99	_	15-Jun-99	01-Jul-99	1-Aug-99
1.3.6.2.3.3	Base-Planes	BNL/ Takai	121.8	2-Jun-97	5-Jul-99	15-Jul-99	5-Oct-99	_	15-Jun-99	01-Jul-99	1-Aug-99
1.3.6.3.3.1	Barrel Crates	BNL/ Takai	136	2-Jun-97	31-Mar-99	01-Jun-99	1-Jun-99	_	15-Jun-99	01-Jul-99	1-Aug-99
1.3.6.4.3.1	Power Bus	BNL/ Takai	163	15-Jun-97	15-Jul-98	15-Mar-99	15-Nov-99	_	15-Dec-99	15-Feb-00	15-Feb-00
1.3.6.4.3.5	Power Supplies	BNL/ Takai	0	1-Mar-99	1-Sep-99	01-Jun-00	1-Jan-01	308.9	15-Jun-00	01-Jul-00	1-Aug-00
1.3.6.4.3.6	Power Cables	BNL/ Takai	0	1-Mar-99	1-Sep-99	01-Jun-00	1-Jun-00	108.7	04-Jun-00	01-Jul-00	1-Aug-00
1.3.7.1.3.1.5	FEB Production Board	Nevis/ Parsons	228.4	15-Oct-96	30-Jun-00	15-May-00	29-Jun-01	_	29-Jun-01	01-Jul-01	1-Oct-01
1.3.7.1.3.2	FEB Production Assembly	Nevis/ Parsons	141.8	15-Oct-96	30-Jun-00	15-May-00	29-Jun-01	_	29-Jun-01	01-Jul-01	1-Oct-01
1.3.7.2.3	SCA Production	Nevis/ Parsons	1,089	15-Oct-96	1-Mar-00	15-Apr-00	30-Jun-00	_	1-Apr-00	1-Apr-00	3-Jul-00
1.3.7.4.3	Optical Links	SMU/ Stroynowski	71.4	1-Mar-99	1-Mar-01	15-May-00	15-Jun-00	468.3	30-Apr-02	1-May-02	19-Jul-02
1.3.8.1.3	Layer Sum Boards	Pittsburgh/ Cleland	291.6	15-Jul-96	2-Aug-99	1-Mar-00	1-May-00	_	30-Mar-00	1-Apr-00	7-Jun-00
1.3.8.2.3	Receiver/Monitor Boards	Pittsburgh/ Cleland	371	31-Dec-98	1-Nov-99	1-Mar-00	1-May-00	-	15-May-00	01-Jun-00	7-Aug-00

WBS	Component	Institution/ Resp. Person	Proj Cost (FY97 K$)	Design Reviews			PRR	Mgmt Cont Cost (FY97K$)	PM Approval	Bid Evaluation	
				Conceptual	Critical	Final				RFP Issued	Eval. Complete
1.3.9.1.3.1.2	DSP	Pittsburgh/ Cleland	0	15-Mar-99	1-Mar-01	1-Jun-02	1-Jul-02	296	30-Apr-02	1-May-02	19-Jul-02
1.3.9.1.3.1.3	FIFO	Pittsburgh/ Cleland	0	15-Mar-99	1-Mar-01	1-Jun-02	1-Jul-02	164	30-Apr-02	1-May-02	19-Jul-02
1.3.9.1.3.1.4	DPRAM	Pittsburgh/ Cleland	0	15-Mar-99	1-Mar-01	1-Jun-02	1-Jul-02	133.6	30-Apr-02	1-May-02	19-Jul-02
1.3.9.1.3.1.5	FPGA	Pittsburgh/ Cleland	0	15-Mar-99	1-Mar-01	1-Jun-02	1-Jul-02	81	30-Apr-02	1-May-02	19-Jul-02
1.3.9.1.3.1.6	PCB	Pittsburgh/ Cleland	0	15-Mar-99	1-Mar-01	1-Jun-02	1-Jul-02	81.7	30-Apr-02	1-May-02	19-Jul-02
1.3.9.1.3.1.7	Optical Receivers	SMU/ Stroynowski	0	1-Mar-99	1-Mar-01	15-May-00	15-Jun-00	80.8	30-Apr-02	1-May-02	19-Jul-02
1.3.9.1.3.1.8	Optical Transmitters	SMU/ Stroynowski	0	1-Mar-99	1-Mar-01	15-May-00	15-Jun-00	80.8	30-Apr-02	1-May-02	19-Jul-02
1.3.9.2.3.1.1	Optical Receivers	SMU/ Stroynowski	0	1-Mar-99	1-Mar-01	15-May-00	15-Jun-00	80.8	30-Apr-02	1-May-02	19-Jul-02
1.3.9.2.3.1.2	Optical Transmitters	SMU/ Stroynowski	0	1-Mar-99	1-Mar-01	15-May-00	15-Jun-00	80.8	30-Apr-02	1-May-02	19-Jul-02
1.3.10.1.3.1.2	Copper Plates machining	Arizona/ Rutherfoord	120	1-Jan-96	4-Dec-97	13-Nov-98	13-Nov-98	-	11-Oct-98	15-Oct-98	5 -Dec-98
1.3.10.1.3.2.2	Electrodes rods	Arizona/ Rutherfoord	119	1-Jan-96	4-Dec-97	13-Nov-98	13-Nov-98	_	25-Jun-99	1-Jul-99	18-Sep-99
1.3.10.2.3.1.1	Cable Harness	Arizona/ Rutherfoord	180	1-Jan-96	4-Dec-97	13-Nov-98	13-Nov-98	_	07-Apr-99	15-Apr-99	15-Jun-99

WBS	Component	Institution/ Resp. Person	Proj Cost (FY97 K$)	Design Reviews			PRR	Mgmt Cont Cost (FY97K$)	PM Approval	Bid Evaluation	
				Conceptual	Critical	Final				RFP Issued	Eval. Complete
1.4	**Tile Calor.**										
1.4.1.1.3.2.1	Steel Plates	ANL/ Proudfoot	567			01-Nov-97	01-Nov-97	_	25-Mar-98	Complete	Complete
1.4.1.1.3.2.2	Steel Cutting	ANL/ Proudfoot	279			01-Nov-97	01-Nov-97	_	Complete	Complete	Complete
1.4.1.2.3.2.1.2	Girders	ANL/ Proudfoot UC/Pilcher	324				01-Nov-97	87	1-Nov-98	18-Nov-98	4-Dec-98
1.4.1.2.3.3.3	Module shipping to CERN (multiple releases)	ANL/ Proudfoot	154			N/A	N/A	_		14-Aug-99	15-Sep-99
1.4.2.1.3.1	Scintillator wrappers	MSU/ Huston	257			01-Mar-98	20-Apr-98	_		Sole Source	
1.4.3.1.3.1	Photomultiplier	UI/ Errede	352			1-Feb-99	1-Mar-99	328	8-Mar-99	15-Apr-99	15-May-99
1.4.3.2.3.1	3-in-1	UC/ Pilcher	524			03-Dec-98	31-May-99	262	25-Mar-99	1-Apr-99	24-May-99
1.4.3.3.3.1	Drawer Mother Boards (3)	UC/ Pilcher	54			03-Dec-98	31-May-99	_	24-May-99	1-Jun-99	19-Jul-99
1.4.3.4.3.1	Digitizers (3)	UC/ Pilcher	0			26-Feb-99	31-May-99	_	01-Oct-99	15-Oct-99	29-Nov-99
1.4.4.1.3.1.2	End Plates (3)	UTA/ De	117			01-Nov-97	01-Nov-97	91	07-Dec-98	14-Dec-98	4-Feb-99

WBS	Component	Institution/ Resp. Person	Proj Cost (FY97 K$)	Design Reviews			PRR	Mgmt Cont Cost (FY97K$)	PM Approval	Bid Evaluation	
				Conceptual	Critical	Final				RFP Issued	Eval. Complete
1.5	**Muon**										
1.5.1.4.1.X	Al extrusion Tubes	Washington/ Lubatti	913.0			1-Mar-99	30-Apr-99	301.8	1-Jun-99	15-Jun-99	15-Jul-99
1.5.1.4.1.X	End Plugs		491.4			1-Mar-99	30-Apr-99	163.8	1-Jun-99	15-Jun-99	15-Jul-99
1.5.3.3.1.1	Hedgehog Board	Boston U./ Hazen	193.6			2-Feb-99	19-Oct-99	57.4	10-Jan-00	20-Jan-00	20-Feb-00
1.5.3.3.1.2	Mezzanine Board (not including ASD)	Harvard/ Oliver	1,032	2-Jun-99	2-Jan-00	2-Jun-00	01-Sep-00	71.5	10-Jan-01	20-Jan-01	20-Feb-01
1.5.3.3.1.6	ASD ASIC	Harvard/ Oliver	1,210.		1-Oct-99	23-Feb-00	1-Sep-00	_	10-Jan-01	20-Jan-01	20-Feb-00
1.5.4.4.X	Cathodes	BNL/ Polychronakos	181.5			31-Mar-99	01-Jun-99	181.5	15-Jun-99	30-Jun-99	30-Jul-99
1.5.5.4.1.1	ASM board (including all ASIC's)	BNL/ O'Connor	711.0		2-Oct-00	5-Jan-01	30-Apr-01	543.5	15-Apr-01	30-Apr-01	30-Jun-01
1.5.5.4.1.2	Data Concentrator	BNL/ O'Connor	148.2	2-Jan-00	2-Oct-00	30-Jun-00	30-Jul-00	_	5-Aug-00	9-Aug-00	30-Oct-00
1.5.6.3.1	Bars	Brandeis/ Bensinger	0	01-Jun-99	01-Sept-99	01-Nov-99	01-Nov-00	169.4	15-Jan-01	15-Mar-01	15-May-01
1.5.6.3.3.1	Almy's	Brandeis/ Bensinger	0	01-Jun-99	01-Sept-99	01-Nov-99	01-Nov-00	281.8	15-Jan-01	15-Mar-01	15-May-01
1.5.6.3.3.2	Lasers	Brandeis/ Bensinger	0	01-Jun-99	01-Sept-99	01-Nov-99	01-Nov-00	226.1	15-Jan-01	15-Mar-01	15-May-01

Glossary

ATLAS (<u>A</u> <u>T</u>oroidal <u>L</u>HC <u>A</u>pparatu<u>S</u>) - A general-purpose particle detector to be installed at Point 1 of the LHC ring. Distinctive features of ATLAS are a large volume, air-core toroidal magnet providing good momentum resolution and sign discrimination for muons and a fine-grained liquid argon electromagnetic calorimeter.

CERN (European Organization for Nuclear Research)- An intergovernmental organization established by Convention signed in Paris on 1 July 1953, revised on 17 January 1971. Also known as the European Organization of Particle Physics.

CERN Council - The governing body of CERN, made up of representatives of all Member States.

CERN-U.S. Co-operation Committee- A committee established by the International Co-operation Agreement of December 1997 between CERN and the DOE and NSF concerning Scientific and Technical Co-operation on Large Hadron Collider Activities. The charge to the Committee is to monitor and facilitate activities undertaken under the agreement, with particular emphasis on matters relating to areas of involvement of U.S. contractors and grantees. The CERN Co-Chair is the CERN Director General. The U.S. Co-Chair is the Associate Director for High Energy and Nuclear Physics of the Office of Science in the DOE. The NSF is represented on the Committee by the Assistant Director for Mathematical and Physical Sciences.

CMS (Compact Muon Solenoid) - A general purpose particle detector to be installed at Point 5 of the LHC ring. A distinctive feature of CMS is a high field solenoid surrounding a precision tracker providing high precision spatial information for decay vertices and particle tracking.

Host Laboratory - A designated DOE laboratory that has management oversight responsibilities for U.S. LHC Accelerator, U.S. ATLAS, or U.S. CMS activities.

JOG (DOE/NSF Joint Oversight Group) - The combined DOE/NSF operating group for the U.S. LHC Program. The Director of the DOE Division of High Energy Physics and the Director of the NSF Division of Physics serve as co-chairs of the JOG.

LHC (Large Hadron Collider) - A particle accelerator at CERN that will collide two counter-rotating beams of protons, each with an energy of up to 7 trillion electron volts. The beams will collide at four intersection points at which appropriate particle detectors will be located. The accelerator will be fed by an existing cascade of lower-energy accelerators.

LHC Activities - The LHC project, the exploitation of the LHC accelerator and the LHC experiments and supporting research and development, and other LHC-related activities. International Agreement, Article I, 1.6)

LHC Program - The program for carrying out LHC Activities.

LHC Project - The activities by CERN to build the LHC accelerator and to contribute to the construction of, and to provide co-ordination and support for, the LHC experiments. (International Agreement, Article I, 1.5)

RRB (Resource Review Board) - An oversight board, with representatives of the concerned funding agencies and the CERN management, for each of the LHC detectors, ATLAS, CMS, which reviews and allocates resources required for the project to proceed on cost and schedule. The Co-Chairs of the U.S. DOE/NSF JOG are ex-officio members of the RRB.

U.S. LHC Construction Project - U.S. participation in the construction of the LHC accelerator and in the design and fabrication of the ATLAS and CMS detectors. Funding in the amount of $450M has been provided in the DOE budget plan and $81M in the NSF budget plan. Details of the U.S. "deliverables" are found in the respective Project Management Plans.

U.S. LHC Operations and Maintenance Project - U.S. participation in the acquisition of data during LHC operations and maintenance of the LHC detectors following commissioning. The Project is an element of the U.S. LHC Research Program. It has two components, U.S. ATLAS and U.S. CMS.

U.S. LHC Program - U.S. participation in construction of the LHC Accelerator and construction and operation at CERN of the ATLAS and CMS detectors. The U.S. LHC Program has two components, the U.S. LHC Construction Project and the U.S. LHC Research Program.

U.S. LHC Projects - The U.S. LHC Construction Project and the U.S. LHC Research Program are comprised by a number of well-defined sub-projects, e.g., U.S. LHC Accelerator, is under the U.S. LHC Construction Project. The collection of these sub-projects is referred to collectively as U.S. LHC Projects.

U.S. LHC Research Program - U.S. participation in the operation of the LHC detectors and in the physics investigations enabled by the detectors, following completion of the facility and commissioning of the detectors.

U.S. LHC Software and Computing Project - Development and operation of the computing and networking facilities and development of the software required for effective U.S. participation in the LHC Research Program. The Project is an element of the U.S. LHC Research Program. It has two components, U.S. ATLAS and U.S. CMS.